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TECHNOLOGY ROADMAP ENERGY EFFICIENCY IN CALIFORNIA'S FOOD INDUSTRY

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial / Agricultural / Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation
-

What follows is the final report for Contract No. 500-03-010, conducted by the California Institute for Food and Agricultural Research (CIFAR). The report is entitled *Technology Roadmap: Energy Efficiency in California's Food Industry*. This project contributes to the Industrial / Agricultural / Water End-Use Energy Efficiency Program.

For more information on the PIER Program, please visit the Energy Commission's website www.energy.ca.gov/pier/ or contact the Energy Commission at (916) 654-5164.

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Abstract

California's \$50 billion food processing industry is an important, diverse, and dynamic sector of California's economy, and the third largest industrial energy user in the State. Over the past 20 years, such pressures as urbanization, regulations, higher costs for energy, water, and other resources, global competition, and limitations on effluents have motivated the food processing industry to search for ways to reduce energy and water use, while maintaining product quality and increasing productivity. To help the industry meet these goals, the California Institute of Food and Agricultural Research formed a Food Industry Advisory Council of industry and technology experts. This group prioritized research that would help the industry meet their objectives, and developed a vision and plan for the future. Their findings, bolstered by input from public forums, are presented in this Roadmap, along with recommendations for the future.

Keywords

California food processing industry, food processors, energy use, water use, energy efficient food processing technology, California Institute of Food and Agricultural Research, Food Industry Advisory Committee, food industry roadmap

Executive Summary

The food processing industry in California is larger than that in any other state and is an important, diverse, and dynamic industrial sector in California's overall economy. Building upon the premier agricultural industry, food processing is a \$50 billion dollar industry and the third largest industrial energy user in the state. California's great Central Valley is home to more than 3,000 factory sites and has the world's largest single factory sites for processing fluid milk (California Dairies, Inc.), cheese (Hilmar Cheese Company), milk powder/butter (California Dairies, Inc.), wine (E & J Gallo), and poultry (Foster Farms).

Over the past 20 years, increasing population and urbanization have brought on greater regulatory requirements and sharper competition for water and energy. Co-production of wastes and its associated liabilities has become a significant cost factor and limiting factor to growth of operations. Increasing labor costs, high natural gas and electricity prices, the 2001-2002 energy reliability crises, environmental regulations, higher costs for operating older, inefficient factories, and global market competition have created a challenging economic environment for food manufacturing firms in California. In combination, these factors resulted in factory closures (e.g., Del Monte Foods, San Jose; Hunt Wesson, Fullerton and Davis; and Tri Valley Growers, Modesto, and Gridley) and consolidation of food processing facilities across the state.

Despite the difficulties, the food industry continues to invest in California to supply the most important market with quality food products. Some large, newly constructed factories (Cheese and Protein International, Tulare; Brawley Beef, Brawley) and pilot plants (ConAgra, Irvine; Creative Research Management, Stockton) have incorporated automated and energy efficient technologies to achieve economic advantages. Among the technologies are those with the ability to track and trace food at all points in the process.

On behalf of the California Energy Commission (Energy Commission), the California Institute of Food and Agricultural Research (CIFAR) established a Food Industry Advisory Council (FIAC) comprising industry and technology experts to lead discussions aimed to determine the state of the industry, prioritize research needs, and develop a vision and plan for the future. CIFAR facilitated this process and subsequently, held several public forums and meetings to develop the California food processing roadmap. These outcomes supported the Energy Commission's Public Interest Energy Research Program.

The FIAC set an agenda for a research program and proposed an industry vision with missions and targets:

- Vision: To continuously improve the global competitiveness of the diverse California food industry with respect to improving energy and productivity efficiencies and reducing water use.
- Mission: To manage energy and other resources to meet or exceed all standards and benchmarks.
- Target: To identify cost-effective savings with payback within 2 years.

The committee met several times and further communicated to complete the industry-driven program and implementation plan. Nine priority research and development areas were identified, in addition to targets and possible approaches, aimed directly at improving energy and productivity efficiencies and reducing water use in California's food processing industry.

The resulting roadmap sets research priorities for the industry in nine broad tracks:

ES-1. Research and Development Needs Ranked Order of Priority

Optimize Equipment and Utilities
Validate Existing Technologies
Improve Thermal Efficiencies
Optimize Cold Chain Management
Improve Power Quality and Reliability
Improve Water Use Efficiency
Reduce Supply Chain Waste
Ensure Food Safety and Security
Develop Seasonal Infrastructure

Each of these tracks is distinct. However, there are many instances where implementation of improvements in one technology area may have implications that overlap in other systems. The central objective of the research program is to reduce the power required to produce a unit of production in the food processing process. The target is to achieve 20 to 30 percent energy use productivity improvements.

The future utilization of energy resources will require a multi-disciplinary approach across industries. The recommendations and conclusions of the committee are the result of applying an overall systems approach whenever possible in order to incorporate multiple variables and efficiencies into a total integrated and process controlled operation. Progress in single isolated technical areas, such as pumping systems, new materials, or refrigeration improvements, will not be sufficient. Inter-related research projects conducted in a parallel and coordinated manner will be much more powerful. To this end, the roadmap calls for coordination with the US Department of Energy and industry organizations to ensure that PIER research will be done in concert with other projects utilizing crosscutting technologies.

1.0 Introduction

1.1. Overview of the Industry

The food and beverage industry in California is highly diversified. It comprises more than 3,000 plants processing commodities that can be sourced from over 79,000 farms. About 240 commodity and trade associations represent food and agricultural interests in California. The dynamic nature of the food processing industry has made its precise characterization difficult. However, some long-term trends within sectors of the industry are apparent and are described in Appendix A.

California ranks 5th in the world in agricultural production (\$27.6 billion in 2002), and first in the U.S. for total food processing output, when defined as total value of shipments that vary over a range of \$41.8 billion dollars to greater than \$50 billion dollars in 2002 (Sullivan, 1999, CLFP and personal communications, 2004).

California is first in the nation in production of milk, milk powder/butter, fruits, vegetables, wine, and almonds; second in cheese; fifth in meat; and tenth in grains (CDFA, 2002). It accounts for 20% of U.S. production of milk at 35 billion pounds, 50% of milk powder and butter, and more than 40% of processed fruits and vegetables, with individual commodities estimated as: tomatoes, 95%; black ripe olives, 100%; fruit cocktail, 100%; pears, 40%; prunes, 100%; raisins, 100%; strawberries, 90%; almonds, 100%; and pistachios, 100% (CLFP data, 2001 and Figure 1).

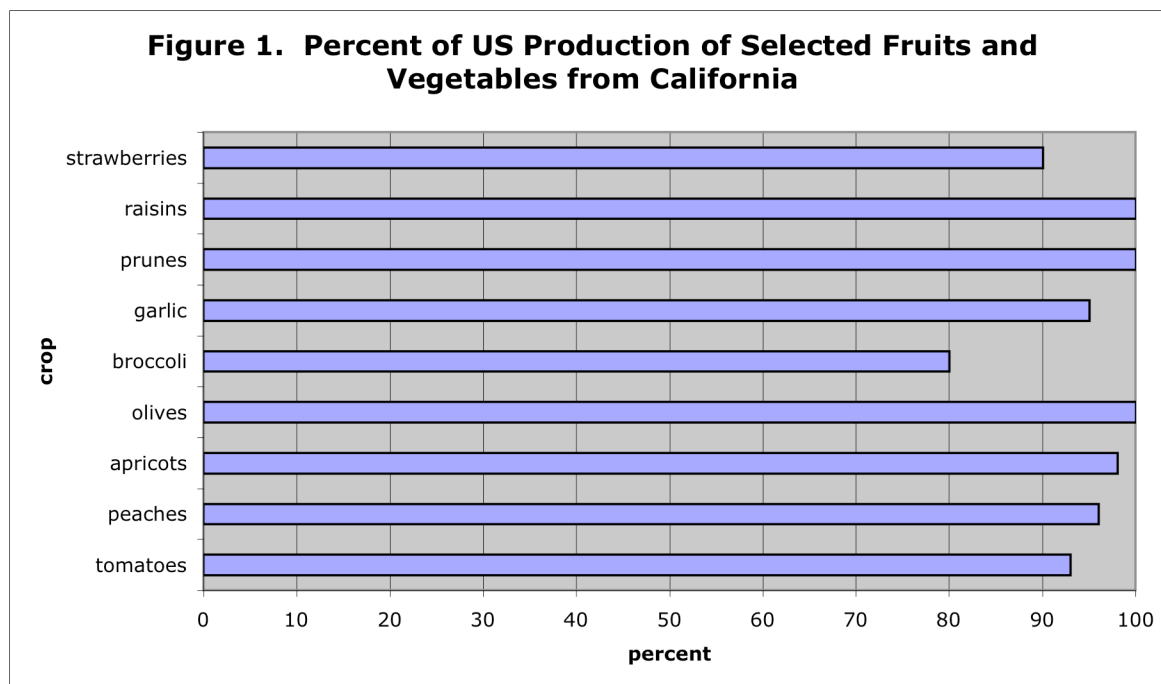


Figure 1. Percent of U.S. production of selected fruits and vegetables from California

Tomato processing is the most dominant category within the fruit and vegetable sector, comprising over 80% of the output in tons (CLFP data, Figure 2).

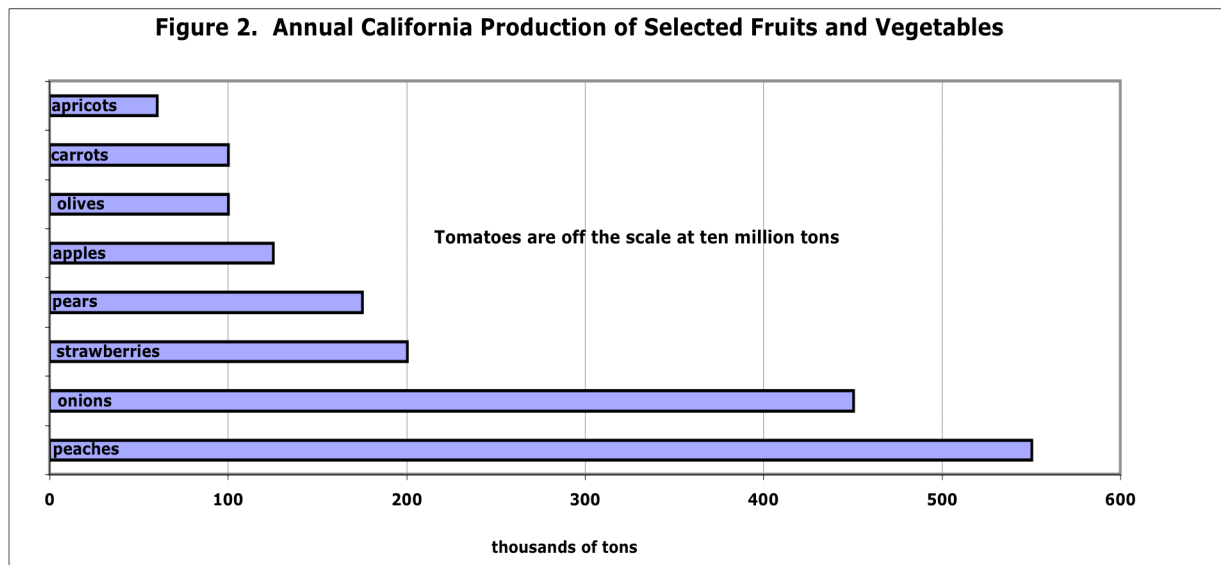


Figure 2. Annual California production of selected fruits and vegetables

U.S. production of almonds and pistachios is 100% from California, and almonds are the top agricultural export crop in California, representing 13% of the total export value in 2002 (data from CDFA and UC Davis).

The diversity of California’s agriculture across all sectors of food operations is reflected in the range in size of the processing facilities. They include all types and sizes, from the “Mom and Pop” shops to the largest single site operations in the world. California is home to the world’s largest single-site manufacturing plant for cheese (Hilmar Cheese, Hilmar); tomato products (Morningstar Packing, Williams); poultry (Foster Farms, Livingston); and wine (E & J Gallo, Livingston). A list of the major food processors with plants in California is given in Appendix B. This report includes only those broad sectors of food processing that require the most water and energy namely, fruits and vegetables; dairy (cheese, milk powder/butter); meat (beef, poultry); and wine.

One way of expressing the value of processing sectors is to describe them in terms of the unprocessed commodities. In this report, we want to emphasize the impact of value-added processing and show both the total value of the top unprocessed food commodities (Table 1) and the added value of processing these commodities (Table 2). The values shown in Table 2 were determined by organizations representing specific sectors and should be regarded as minimum values. Even though only the major energy-use sectors are tabulated in the list in Table 2, the added value for processed commodities was found to be \$63.9 billion, more than twice that of the original commodity value. This is in the same range as the total value for all processed commodities determined in 1996 by the U.S. Census Bureau to be \$41.4 billion, and reflects the growth since 1996.

Table 1. The value of California's top food commodities*
(CDFA data, expressed in millions of dollars)

1	Milk and Cream	\$3,812
2	Grapes, All	\$2,579
3	Lettuce, All	\$1,278
4	Cattle and Calves	\$1,229
5	Almonds	\$1,190
6	Strawberries	\$ 991
7	Tomatoes, All	\$ 926
8	Oranges, All	\$ 559
9	Broccoli	\$ 488
10	Carrots	\$ 460
11	Chickens, All	\$ 452
12	Avocados	\$ 358
13	Pistachios	\$ 336
14	Potatoes, All	\$ 307
15	Walnuts	\$ 305
16	Lemons	\$ 287

*The values represent commodity values

Table 2. Estimated value-added for food processing in California

Food Processing Sector	Value (in billions)
Fruits & Vegetables ¹	\$10
Dairy ²	\$35
Beef and Poultry ³	\$8.5
Wine ⁴	\$9.9
Rice ⁵	\$0.5
Total	\$63.9

¹CLFP data, 2003, post harvest only and does not include irrigation water.

²N. Fletcher, 2003, Dairy Issues Forum

³Personal Communications, California Beef Council, 2002 (\$5B); Bill Mattis, California Poultry Federation, 2004, (\$3.5B)

⁴Wine Institute, 2003

⁵California Rice Commission, 2004

The food processing industry consumes an enormous amount of the water and energy resources available to the State of California. The amount of water and energy (electricity and natural gas) used by major food processing sectors were estimated on an annual basis, employing a variety of sources with verification by representatives of the dominant processing facilities within each sector as estimated in Table 3.

Table 3. Estimated annual water and energy use of major food processing sectors in California

Food Processing Sector	Water (Million Gallon)	Gas (Million Therm)	Electricity (Million KWH)
Fruits & Vegetables¹	30,000	300-400	600-800
Dairy			
Cheese²	600	43	583
Milk Powder/Butter³	360	33	130
Meat			
Beef⁴	1200	5	88
Poultry⁵	2000	40	360
Wine⁶	2900	23	406
Rice⁷	Negligible	41	316
Refrigerated Warehouses⁸	Negligible	Negligible	1000

¹CLFP data, 2003. Post-harvest only and does not include irrigation water.

²Personal communication, T. Struckmeyer, Hilmar Cheese, 2004. Does not include water and energy for production of raw milk but does include whey processing, which is an integral part of cheese making.

³Personal communication, J. Gomes, California Dairies, Inc., 2004

⁴Personal communication, Jim Oltjen, UC Davis, 2004 (608gal/animals slaughtered) and Cattle Buyers Weekly, Dec 2003 (# animals slaughtered), and personal communication, J. Maxey, Beef Packers, Fresno. Numbers reflect slaughtering plants only.

⁵Personal communication, Bill Mattis, California Poultry Federation, 2004.

⁶Alcohol, Tobacco, Tax and Trade Business, Dec. 2001 (574 M gal wine produced), and Wine Institute report (5 gal water per gal wine), does not include water inputs to production of grapes.

⁷Personal communication, J. Mannapperuma, 2003 (drying only).

⁸Personal communication, International Association of Refrigerated Warehouses, and World Food Logistics Organization, 2004.

From this table, it is clear that the food industry in general, and fruit and vegetable processing in particular, requires significant amounts of water for their operations. In a processing season, many California fruit and vegetable plants use 0.5 to 3 million gallons per day. On average, about 88% of the water used in fruit, vegetable, and wine operations becomes effluent water. Thus, water management is very important. Further, fruit and vegetable processing generates the most effluent water by far when compared to the other major energy intensive sectors (Table 4).

Table 4: Estimated total annual effluent water discharge within major food processing sectors in California

Food Processing Sector	Total Water Discharge (Billion Gallon)
Fruits & Vegetables ¹	29
Dairy	
Cheese ²	2.1
Milk Powder/Butter ³	1.0
Meat	
Beef ⁴	1.0
Poultry ⁵	1.2
Wine ⁶	2.5

¹Personal communication, Ed Yates, CLFP, 2004 (estimated as 88% of water use).

²Personal communication, T. Struckmeyer, Hilmar Cheese, 2004.

³Personal communication, J. Gomes, California Dairies Inc., 2004.

⁴Personal communication, J. Maxey, Beef Packers, Fresno. 2004.

⁵Personal communication, Bill Mattis, California Poultry Federation, and Dr. Jurgen Strasser, Process and Equipment Technology, 2004.

⁶Estimated as 88% of water use.

With such high levels of effluent generated, many fruit and vegetable operations have examined technologies that might reduce their effluent volume and allow in-plant reuse of this water stream. Separation of suspended and dissolved solids from the effluent water has been found to reduce the effluent load (BOD, COD) discharged from the plant to water treatment plants and has offered alternative uses for the separated solids. Technologies such as membrane filtration, in combination with pre- and post-treatment have proven useful (e.g., to Sunkist in Bakersfield).

In addition, increasing demand for water treatment, especially in urban areas can forcing cities to allocate maximum allowable levels of effluent per plant. This limitation can in turn constrain the expansion of process operations. For example, Petaluma Poultry Processors could no longer expand plant capacity because it had reached the maximum level of effluent that could be processed by the City of Petaluma municipal treatment facility.

While energy use is significant in food processing operations, energy efficiency has not been a priority until the past five years, when greater competition for limited resources and the resultant higher energy prices raised operational costs significantly. Of greater concern for the food processing industry has been the quality and reliability of available power, since any interruptions in utility service can result in significant production losses and impact the safety of the product.

Table 5 breaks down electricity and natural gas use by food processing sectors into energy-using systems. The values and percentages are estimates, as there is a wide range in types of plants within each category. Within the fruit and vegetable sector, tomato processing dominates operations in thermal processing. In contrast pumping and refrigeration are the dominant uses of energy in dairy and wine processing.

Table 5: Estimated distribution of energy (%) within major food processing sectors in California

Food Processing Sector	Pumps Motors Fans Conveyors Lighting	Pasteurization Heating Systems Evaporators Dryers Sterilization	Cooling Freezing Refrigeration	Sanitation Clean in Place
Fruits & Vegetables	10	70	15	5
Dairy				
Cheese	35	40	20	5
Milk Powder	25	55	15	5
Meat				
Beef	30	20	40	10
Poultry	30	20	40	10
Wine	50		40	10
Rice (drying)	20	80		
Refrigerated				
Warehouses	15		80	5

1.2. Specific Characteristics of Industry Sectors

1.2.1. Fruit and Vegetable

California is the leading producer of fruit and vegetables in the United States, and processing fruits and vegetables is the largest food sector in California, creating about \$50 billion of added value a year. This sector includes 184 companies that operate 229 factories to produce \$10 billion of processed fruits and vegetables a year (20% of the nation's total). This is \$1 billion more in production than that of the next two states combined. This sector produces more than 500 million cases of canned products and 1.8 billion pounds of frozen products every year (CLFP, 2002).

Energy costs for this sector are increasing, and large processors are looking for ways to improve efficiencies and ensure reliable supply of high quality power. The costs for electricity in 2001 were about \$70 million but are expected to escalate significantly to about \$140 million. Prior to 2000, the annual cost for natural gas was around \$90 million. In 2000 it was \$135 million, and in 2001 it dropped to \$100 million. The fruit and vegetable industry's energy use is highly seasonal, with 80% of natural gas and 60% of electricity consumed during the peak summer processing season of mid-July to mid-October (CLFP, 2002). Demand-side energy management is increasing, driven by incentives, rebates, and rate increases. Further, as steps to affect the

supply side become more limited, companies are mainly focusing on the demand side of managing energy costs. In addition, this food processing sector uses by far the highest quantity of water compared to other food processing sectors in the state.

It should be noted that the fresh-cut produce category has not been included with traditionally processed fruits and vegetables, although it involves significant water washing, cutting, conveying, mixing, controlled atmosphere packaging, and refrigeration. Three plants in the Salinas area dominate this sector, Fresh Express, Dole Packaged Products, and River Ranch. The sector has grown at a rate of about 11% (IFPA data, 2002) in the last few years, constrained by regulatory issues related to water and air quality. The numbers for energy and water use plus effluent water disposal given in Tables 3 and 5 would be higher if fresh-cut were included.

1.2.2. Dairy

California's significant dairy industry is based on 1.5 million milking cows that delivered 35 billion pounds of milk in 2002, with 75% of the available milk solids being processed into cheese, milk powder, and butter products. The state's milk production has grown by almost 12 billion pounds since 1993, and in 2002, growth in production of milk (5%), cheese (5%), milk powder (9%) and butter (11%) set new records compared to the previous year (Cheese Reporter, 2003). Milk production (80%) is largely controlled by four major dairy cooperatives: California Dairies, Inc. (Artesia); Land O' Lakes (Tulare); Dairy Farms of America (Modesto); and Humboldt Creamery Association (Fortuna).

In 2003, a situation occurred that slowed the rate of growth in California's dairy industry. Low milk prices at farm level reflected an imbalance between supply and demand for milk and dairy products. A new program called "Cooperatives Working Together" (CWT) was formed to reduce supply and stabilize the industry. Prices rose and production growth slowed in 2003 to a 1% growth in production of milk compared to the previous year, with cheese, powder and butter leveling off also. Milk is produced in 37 counties, although only five of these counties make up 68% of the production: Tulare, Merced, Stanislaus, San Bernardino, and Kings, (Cheese Reporter, 2003)

A significant amount of electricity is required to operate water and vacuum pumps for milking, and refrigeration for cooling. Incorporating variable frequency drives in pumps for milking and refrigeration and using premium high efficiency motors have been shown to improve energy efficiency (PG&E report, 2002).

The two largest cheese plants in California are Hilmar Cheese Company (Hilmar) and Leprino Foods (Tracy). In addition, a large cheese-whey processing plant (Cheese & Protein International [CPI], Tulare, a joint venture between Land O'Lakes and Mitsui Inc.) was completed in 2002. CPI incorporates the state-of-the-art systems for efficient separations and for water and energy use. Across the board, large cheese processors have modern facilities that incorporate new technologies to keep costs down and ensure safety and quality.

California Dairies Inc. produces about 50% of the milk powder /butter, with Land O'Lakes, Challenge, and Humboldt Creamery producing most of the remaining butter. The bulk of milk powder is bagged and sold to the government.

Food safety and security, together with environmental and energy issues, are the primary concern facing the dairy industry. The U.S. dairy industry is recognized as a national security

concern to be protected from incidents, intended or accidental. In addition, large dairies (so-called mega-dairies) are having difficulty in getting operating permits because of environmental issues. There are further constraints on growth because of regulatory issues associated with air and water quality. Energy has become an important factor in their business because of uncertain rate structures and high costs. Processors feel there are few options for favorable future contracts for electricity and natural gas.

1.2.3. Meat

Meat processing plants inspected by the USDA in California in 1999 were estimated at 726, a number that has not varied more than 5% since 1995 when there were 772 plants. The plants inspected include egg, poultry, beef, lamb, and pork and tallow processing facilities, including rendering. Non-commercial entities, such as prisons and university meat labs, are also included in this number. Meat products from California include meat snacks, fresh cut meat and poultry, and prepared foods, such as soups, frozen dinners, and canned meats. Some meat processors, such as Campbell Soup (Sacramento) and Kraft (Buena Park) use meat as a food ingredient. Beef and poultry represent the bulk of meat processing in California.

1.2.4. Beef

The California beef industry has a capacity of more than 2 million beef cattle per year. Beef Packers, Inc. (Fresno) is the largest beef packing plant west of the Rocky Mountains, and it continues to expand with new construction, including its own wastewater treatment plant. The second largest plant in California is newly constructed Brawley Beef of Imperial Valley, which is utilizing irradiation to ensure safety of its products. Three other beef processors complete the big five that dominate the state's beef industry: Harris Ranch Beef Company (Selma), Central Valley Meat Company (Hanford), and Hallmark Meat Packing (Chino). Energy use is primarily associated with refrigeration and sanitation.

1.2.5. Poultry

The poultry industry is significant and processes on average 250 million birds a year (California Poultry Federation, 2004). The largest single poultry plant in the world is Foster Farms (Livingston) where about 0.5 million birds per day are processed. Foster Farms and Zacky Farms (Fresno) represent the largest plants in California. Petaluma Poultry Processors (PPP, Petaluma) represents a medium-sized processor that has incorporated technology to minimize chemical inputs and maximize energy and water use efficiencies in plant operations. PPP has replaced chlorine with chlorine dioxide as a sanitizer. Temperature regulation and refrigeration are the primary uses for energy in the plant, and between 7-10 gallons of water are used per bird.

1.2.6. Wine

California ranks 4th in the world in wine production after Italy, France, and Spain. The state is responsible for 90% of all U.S. wine, producing more than 444 million gallons of wine valued at \$2 billion a year in over 847 commercial wineries (1998, Wine Institute). E & J Gallo is the largest wine producer and wine supplier in the United States., having fully integrated energy and water efficient systems plus waste utilization on their plant sites (Foodnavigator.com, 2004).

1.2.7. Refrigerated Warehouses

There are 77 reported cold storage units in California that require at least 1000 million kWh of electricity per year. This sector is an important service category of California's food industry and it is growing. The warehouses are networked through two organizations: The International Association of Refrigerated Warehouses (ARW) and the World Food Logistics Organization (WFLO). The members of ARW are operators of public refrigerated warehouses (distinct from warehouses maintained by the food processor before shipment of finished product).

1.3. Trends

1.3.1. Food product reformulation

Food product reformulation, also called co-packing, is a growth segment of California's food industry, as indicated by the number of food reformulation facilities that have been established or expanded recently. About two-thirds of the food processing plants belong in this sector, because their raw materials are been processed once, (e.g., tomato paste) and then reprocessed into prepared food products and packaged for sale. Mexican foods, salsas, pasta, soups, organic soy, and rice milks are some of the products manufactured, with most of the plants being located close to population centers.

1.3.2. Commodity processing

Commodity processing is being consolidated into centrally located and newly automated plants, resulting in closure of smaller, less-efficient plant or plants overcome by urban sprawl. This trend is apparent in facilities for fruit and vegetable canning (e.g., tomato, asparagus, and artichoke canning). Most new construction and expansion of plants is located in areas where environmental compliance is achievable. A number of pilot facilities have emerged recently (e.g., Creative Research Management, National Food Laboratory) to demonstrate the value of applying new processing and packaging technologies (e.g., electron beam, x-ray, aseptic line, pulsed electric field, high pressure) to food operations.

1.3.3. New processing methods

New processing methods are being employed with the increase in multicultural food production, based upon ingredients provided by a wide range of sources. The trend to use automated processing equipment and sensors is reducing overall energy use by making the process more efficient with less human error, resulting in less re-work and waste.

1.3.4. Complete and better byproduct utilization

Complete and better byproduct utilization in processing operations has become increasingly important to profitability. California agriculture-based processing industries will further benefit from better utilization of materials that go to waste and/or animal feed. These materials often contain useful nutraceutical components that are not being recovered because appropriate technologies needed for their cost-effective recovery have not yet been developed.

1.3.5. A food distribution system

A food distribution system using supply chain infrastructure and management is essential to cost-effective delivery of food from farms to consumers. It is of increasing importance to ensure the safety and security of the food system for delivery at any time and to any location for a wide range of product categories. Essential components to such a system are illustrated in Figure 3.

Figure 3: Supply Chain Management

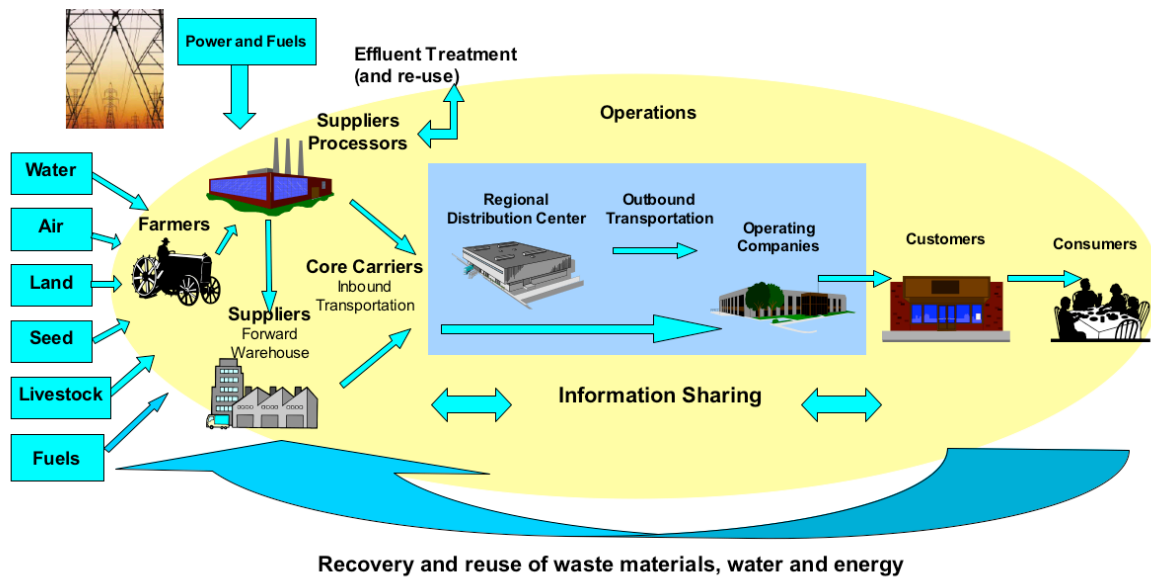


Figure 3. Supply chain management

Closely networked systems embrace all components of the supply chain on a real-time basis. The components of the supply chain must include high speed communications, “track and trace,” appropriate temperature and moisture controls, transportation systems to originate from a multitude of suppliers and deliver through many intermediate points to a multitude of retailers and consumers. Water and waste management systems are integrated into the supply chain to support sustainable and cost-effective operations. There is also increasing pressure on producers and processors to implement socially responsible strategies (e.g., animals, environment). The consumers want to know where their food is coming from and that the process of making it is consistent with their values.

1.3.6. Water supply, energy supply, and sewage removal

Water supply, energy supply, and sewage removal are essential to most food and beverage facilities. These services, once inexpensive and taken for granted, have become expensive and sometimes unreliable, placing California food processors at a serious disadvantage in the face of intense competition from both domestic and foreign producers. For example, the impact of the availability of foreign fresh and processed food imports, including peaches, garlic, apples and rice, has devastated some of California’s fresh and processed food markets. The industry has responded to these challenges with improved conservation, relocation, self-reliance, and other innovative approaches to water supply, energy supply and sewage removal. (Examples: protein recovery from cheese whey, zero discharge in olive processing, sugar recovery for fermentation in raisin processing, cogeneration, standby generators, demand management systems.)

1.3.7. Food safety

With animal disease, pest outbreaks, and food-borne illness escalating worldwide, food safety is still a top issue for consumers. Much of the discussion continues to focus on the pathogen jump from animals to humans, which has particularly impacted the meat industry. Future concerns will likely revolve around toxins in the food supply (e.g., in grain storage). The increase in microbial counts in the air has led many processors to think about different practices, such as conveying products in open areas, and bulk packaging products for shipment. Biomonitoring will increasingly be used to track the consequences of environmental pollutants on health.

Food safety and security are areas of intense recent attention and discussion, with increased levels of concern over bio-terrorism and the need to secure facilities, as well as ensure safety of food and food ingredients from foreign sources. Our vulnerabilities to terrorism are adding a new wrinkle of insecurity and are re-defining food production and processing practices. The need for secure facilities is expected to require technologies, such as time clocks with biometrics to sense personal identity, that will increase energy use and sensitivity to power quality.

2.0 Background

The development of a Roadmap for the California Food Processing Industry is an important step in demonstrating that food processing is a major contributor to our State's economy and well being, a major user of electricity, natural gas and water, and a generator of effluents that can influence the quality of the environment. The roadmap will show further that there are major issues that cut across this diverse industry that can be helped or solved by further research, development, and demonstration of existing and new technologies. The above characteristics fit with the goals of the Public Interest Energy Research Program.

2.1. Project Objective

The objective of this project is to create a food processing roadmap that defines a current baseline for energy, water use, and practices, as well as water and air quality considerations, and that points to key needs and directional targets that are dependent on research, development, and demonstration which, if studied and implemented, could significantly increase energy and water efficiency and minimize negative environmental impacts.

2.2. Report Organization

This report is organized into several sections to address the project objectives.

The Introduction provides an overall snapshot of California's diverse food processing industry, but selectively concentrates on the sectors that have the most impact on energy and water. Current data and trends are presented to ensure that this report reflects today's needs.

The Project Outcomes section provides a detailed account of the priority research needs and targets that cut across the various food industry segments and presents the research needs in terms of a roadmap to ensure the Food Industry Advisory Committee's vision, mission and target:

- Vision: To continuously improve the global competitiveness of the diverse California food industry with respect to improving energy and productivity efficiencies and reducing water use.

- Mission: To manage energy and other resources to meet or exceed all standards and benchmarks.
- Target: To provide cost effective savings with payback within 2 years.
-

The Conclusions and Recommendations section leads into the first phase of implementation projects.

3.0 Project Approach

The roadmap was generated through the combined efforts of the membership of the Food Industry Advisory Committee (Appendix C). The California Institute of Food and Agricultural Research at the University of California, Davis, facilitated the process. Using a 1998 technical report as a starting point, the FIAC evaluated impact of the energy crisis to the California food processing industry in meetings held in November 2001 and February 2002. The revised issues were presented at a public meeting June 4, 2002 at UC Davis, and comments were incorporated into the document. Separate industry roadmaps and visioning reports were examined during the course of compiling the California Food Processing Industry Roadmap (Appendix D). The results provide guidelines for PIER's short-term RD&D investments and related activities.

4.0 Project Outcomes: A Vision for the Future of the California Food Industry

The FIAC set the vision and agenda for California's food processing industry. The proposed vision is to continuously improve the global competitiveness of the diverse California food industry with respect to improving energy and productivity efficiencies and reducing water use.

This vision builds upon the supply into, and infrastructure surrounding, California's \$64 billion food processing industry (based on major energy dependent industry sectors listed in Table 3). California is fortunate to have an extensive supply of diverse raw materials for processing to food, feed, and beverages, as well as some of the most advanced processing and packaging, manufacturing, and pilot plants in the United States. California regulations in food and beverages often serve as a model for national Food and Drug Administration (FDA) and U.S. Department of Agriculture (USDA) regulations and policy. In addition, California's food and agricultural system has an extensive support network of government-, industry- and university-based groups to help ensure its health as a strong industry.

California's growing urban population and somewhat anti-business climate have brought new challenges to achieving the above-stated vision. Important "drivers" that have and continue to influence shifts and consolidation in the industry are given in Table 6.

Table 6. Key drivers

Global competition
Safety and security
Energy quality, reliability and cost
Water availability, quality and cost
Waste reduction and liability
Air quality issues
Residue analysis
Cost and quality of labor

The drivers stated in Table 6 are the principle factors influencing competitiveness of the food industry across all sectors, as discussed below:

- **Global competition** is a given but must be kept in balance with domestic needs. There must be balance and similar standards for all countries or there is a need to adjust the price and availability of imported products. Standards need to be identified and put in place with special consideration to safety and security issues.
- **Safety and security** across all sectors is the number one issue facing the food industry. The need to “track and trace” at all point sources within the food chain is redefining processing in favor of automated, controlled systems whenever possible, including the use of appropriate on- and off-line sensors and detectors.
- **Energy**, its quality, reliability and cost, is an important driver in retaining and growing the food processing industry in California. The energy crisis and its fallout have prevented manufacturing operations from changing energy suppliers. No new direct-access contracts are allowed while the state develops new energy policies to address issues concerning existing debt payments, as well as reliability and distribution equity considerations. This restriction, and its underlying uncertainty, is negatively influencing decisions for investment and growth. In addition, reliability in power is essential to processing food: the least perturbation in power can have dramatic effects on the cost and safety of the products. Thus, alternative fuel back-up generators must be in place, further increasing total energy costs, as well as creating air pollution emissions.
- **Water**, its availability, quality and cost, is a significant component in processing food, especially fruits and vegetables. All modern facilities are conscientiously incorporating practices and systems that ensure a high quality of water (sometimes further processing water coming into the plant from city supplies) and maximizing in-plant use and re-use through such technologies membrane filtration systems. Since a controlling factor in the size of plants is the amount of effluent water that can be discharged to municipal treatment facilities, there are increased incentives to reduce this amount by finding ways to clean and re-use the water in the plant.

- **Waste reduction** is a key driver for the industry, with most facilities examining ways to reduce the cost and liability of its solid and liquid waste. Larger operations are separating and concentrating waste streams for use on their property (fertilizer); finding new uses (nutraceuticals, color, flavor); producing biogas energy (from fig and other fruit's processing waste stream); or developing partnerships for co-products (such as Morningstar Packing tomato paste operation in Los Banos providing Kagome with a co-tomato stream that is then concentrated and bulk packed for shipment to Japan.) Land application is becoming less desirable due to the potential for groundwater contamination and associated liability.
- **Air quality** issues are huge in the dairy industry, which needs to develop standard methods for measuring ammonia and other compounds in dairies and reducing odor. Microbial counts in fungi and bacteria have been found at much higher levels than previously in the air of the San Joaquin Valley Region in recent years. This results in more food processing facilities using closed conveyer systems and/or packaging in the plant, rather than relying on their customers to individually package the product. In general, the less open the system and the less human contact, the better.
- **Residue analysis** for certain pesticides, herbicides, and other chemicals that could be present in raw materials and throughout processing has been mandated for food processing operations. Increased regulation in this area is driving the use of automated processing and control systems for data acquisition, analysis, and management.
- **Cost and quality of labor** are sensitive and important issues that directly impact profitability. The availability of cheap labor in other countries is driving some processing operations out of California (ConAgra, Tropicana), and this trend can have long-term negative economic impacts if the difference is not made up in import taxes. The high cost of worker's compensation compared to other states also is hindering the expansion of this industry in California.

Despite all the factors that impact the competitiveness of the food processing industry, existing facilities are retrofitted and new facilities are being built with electronic equipment that requires properly trained personnel. However, the industry continues to have a difficult time hiring well-trained, competent staff that can properly operate automated systems and controls. Although this roadmap does not address the education issue, the Energy in Agriculture Program of the Energy Commission sponsors the delivery of U.S. Department of Energy (DOE) Best Practice training and education workshops on pumps, motors, compressed air, and steam systems. The program is also involved in a U.S. DOE State Technologies Advancement Collaborative (STAC) partnership with other western states to develop a clearinghouse of information service. This service targets cost-effective emerging technologies to reduce energy costs, increase productivity, and improve quality. The partnership includes the states of Oregon, Washington, and Idaho, as well as the California League of Food Processors, the Northwest Food Processors Association, Del Monte Foods, and Lawrence Berkeley National Laboratory.

4.1. **Goals and Benchmarks**

The FIAC set its mission to manage energy and other resources to meet or exceed all standards and benchmarks, followed by a target to provide cost-effective savings, with payback within two years. Table 7 provides a summary of the most significant goals and benchmarks. The next

section outlines specific issues, including targets and approaches recommended for implementation.

Table 7. Goals and Benchmarks

Goals	Benchmarks
Efficient use of energy Distributed power and flexible fuel plants Enterprise Energy and Asset Management Systems Microprocessor-based control systems Integrated unit operations Capture and re-use low grade power Best energy efficiency practices	Reduce energy use (KWh) per “stock keeping unit” by 35%
Efficient use of water resources Capture and re-use water in plant	Reduce water use per “stock keeping unit” by 40%
Total material handling and utilization	95+% of materials utilized; Reduced costs and liability
Safe and secure food supply Track and trace (on-line) Smart cards, radiofrequency identification	“Seal of safety” enhances consumer confidence
Environmental stewardship Adopt new air emission standards	“Sustainable” label enhances consumer loyalty

4.2. Major Research Needs, Approaches and RD&D Targets

The FIAC aimed the detailed research agenda directly at improving energy and productivity efficiencies and reducing water use in California’s food processing industry by identifying nine research areas of need (Figure 4 shows the priority ranking from left to right), along with corresponding targets and approaches.

Figure 4: Needs and Priorities for California's Food Processing Industry

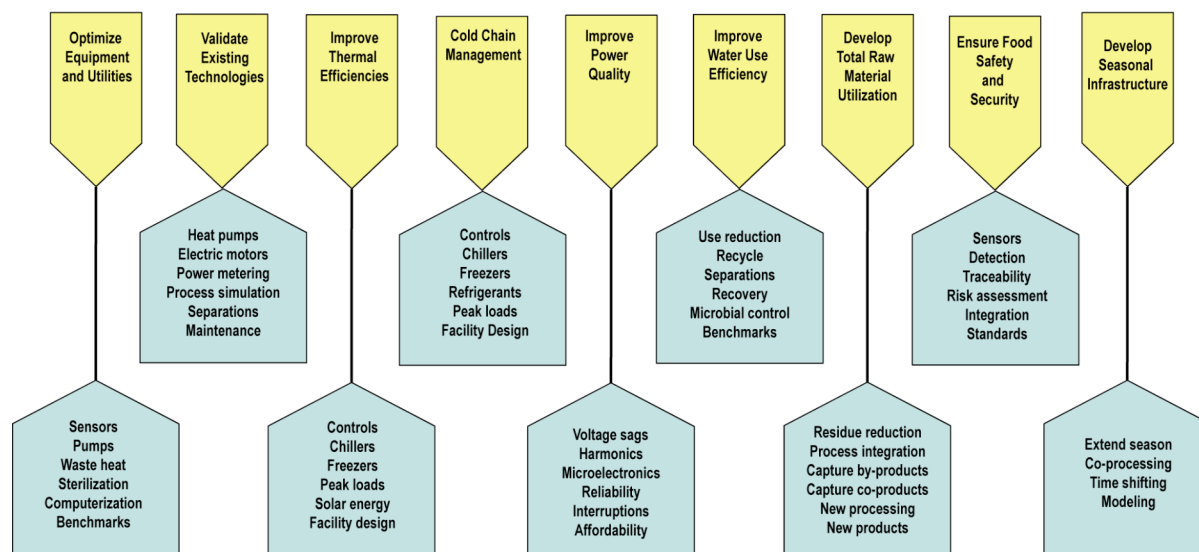


Figure 4. Needs and priorities for California's food processing industry

4.3. Roadmap Recommendations

The following section of the report provides a list of research needs, targets and possible approaches.

4.3.1. Industrial Optimization of Process Equipment and Plant Utilities

Objective: Optimize overall process equipment

Effective implementation of industrial optimization practices offers food processors opportunities for increased efficiency, reduced costs and improved product quality. Industrial optimization facilitates management's ability to make essential operating decisions that translate to a more efficient use of energy while balancing other resources. Industrial optimization practices (software and control equipment) use facility data to characterize process equipment. Design curves are interpreted within the system to generate mathematical representations. The appropriate design data are used to construct a detailed computer model of the equipment used to generate the performance indicators under current operation.

4.3.1.1. Industry Identified Targets

- Identify investments in energy efficiency with two-year payback returns
- Increase plant performance, productivity, and throughput by identifying optimal equipment design and maintenance schedules
- Improve product quality
- Improve maintenance/management decisions and implementation
- Optimize the integration of components into systems that provide for maximum energy efficiency, resource use, and production

4.3.1.2. Industry Suggested Approaches

- Use an overall computer-assisted and systems-based approach to develop appropriate computer monitoring programs.
- Evaluate all process equipment according to design/guarantee conditions to determine if still within specification. Specifically examine power consumption, throughput, pressure ratio, etc., as well as operating points, showing expected operational parameters at normal, min and max conditions
- Recommend new equipment and/or monitoring systems as appropriate.
- Conduct educational and training classes.

4.3.1.3. RD&D Targets

The real benefits from using optimization practices come from the frequent evaluation of equipment performance based on real data. Data can be downloaded onsite or accessed remotely via web-based software. The processed data are applied to the software calculation engine to generate the performance indicators and provide the equipment results. Knowing the operating performance of plant or process equipment will assist operators in troubleshooting problems early, remotely, and at low cost. Thus, comprehensive data on plant operational parameters allows for a wide-ranging comparison of effectiveness and efficiency of different installations and therefore will greatly influence the next cycle of investment decisions.

Technologies that fall within this category include:

- Enterprise management systems
- Asset management systems

4.3.2. Technology Validation

Objective: Validate and transfer emerging and existing technologies in a new process setting

Many technologies used outside the food industry—including new types of power, fuel cells, membrane filtration, ozonation, and aseptic processing—have potential uses in food operations if cost-effectiveness is established. Other potent examples of technologies that reduce energy use include automation that results in more precise temperature control and more efficient utilization of raw materials and bio-based processing technologies, such as the use of enzymes and beneficial microbes to replace mechanical energy. In many cases, the demonstration and validation of a technology to different situations can accelerate its adoption. There is a need for a systematic process of assessment of current developments in technology, sort of a “consumer reports” for industry. DocuLabs is one example of a technology assessment service agency (<http://www.doculabs.com/>). Often a promising technology will require further development in order to be applied in new ways.

4.3.2.1. Industry Identified Needs

- Demonstrate technology
- Apply technologies that are currently used in other industries, such as new types of power, fuel cells, membrane filtration, ozonation, aseptic processing, and biobased processing.
- Establish training and education programs
- Transfer industry experiences and expertise

4.3.2.2. Industry Suggested Approaches

- Establish or utilize a central screening and demonstration facility for technology demonstration, optimization, and transfer to industry
- Adapt equipment through interactions with suppliers and manufacturers
- Provide cost/benefit indices to industry for new and existing technologies and equipment
- Conduct life-cycle analysis of operations
- Develop processes for low-quality energy recovery (e.g., heat pumps)
- Communicate about state-of-the-art motor technology
- Leverage state and federal funding and utility incentives to advance new technology
- Inform food processors of new technologies by providing them with specific information through mailings, forums, etc.

4.3.2.3. RD&D Targets

There are opportunities to improve food processing operations with incorporation of existing technologies if they can be justified economically. Often, food processors are either not familiar

with technology options or do not have the means or the desire to explore new ideas outside their daily operations. Demonstrations of technical viability and cost-effectiveness have been shown to accelerate commercialization of new energy and water efficient technologies. Commodity groups in California have expressed interest in demonstrations of new technology to add value and product options to their businesses. Some technologies that fall within this category follow:

4.3.2.4. Low-quality energy recovery processes (e.g., heat pumps).

- Separation technologies
- Technologies to reduce energy and water use
- Technologies to improve product quality and safety
- Metering, sub-metering, systems overview and process simulation software
- Maintenance systems and resource management
- State-of-the-art electric motor technology

4.3.3. Food Processing Thermal Efficiencies

Objective: Improve energy efficiency in heating, cooling and drying

The California food processing industry is undergoing considerable change, in part because older plants are grossly inefficient and too costly to operate. Many older food processing plants can no longer compete with more modern operations or foreign operations and have closed. Of particular concern is global competition from China, which has lower energy costs and has become the world's largest fruit producer. In addition, China's less stringent environmental regulation and lower labor costs make for more economical operation. Owners and operators of newer plants have to pay close attention to overall efficiencies and resource allocations, such as hot and cold water use, pumping, monitoring and waste. Life cycle analysis is proving to be a useful tool to determine optimal efficiency.

The produce dehydration sector is facing particularly severe energy-linked pressures. Currently the more than 3000 driers and dehydrators that operate in the Central Valley find that energy costs account for up to 60% of the cost of the final dried product. The dehydration process is often inefficient, employing outdated technologies. Further, production is often seasonal and associated with only one commodity. More flexible, strategically located, and portable equipment could provide better utilization of capital. Also, new energy efficient dehydrators and driers could be introduced.

4.3.3.1. Industry Identified Needs

- Develop standard methods for temperature monitoring and control
- Optimize process controls (e.g., moisture sensors)
- Improve efficiency in freezer and dryer configurations
- Integrate heating and cooling operations to capture waste heat
- Improve and maximize energy efficiency of dryers
- Improve and maximize utilization of capital investment of process equipment

4.3.3.2. Industry Suggested Approaches

- Develop standard methods and monitor results
- Develop and use control sensors for temperature, humidity, and time in process operations and in transport and storage facilities
- Adopt automatic control devices and monitoring systems
- Improve facility design by improving efficient, multi-state cooling. Minimize peak rates for electricity use
- Utilize waste heat
- Develop software to integrate and optimize container equipment
- Retrofit existing equipment
- Develop highly efficient refrigerants and compressors (spiral configurations) for heat removal
- Replace old chillers and ensure chillers are maintained at proper temperature
- Consider the use of zone drying and heat pumps
- Maximize the use of lower air temperatures, moisture recirculation, and targeted air flow in tunnels used in dehydration
- Disseminate information in public forums
- Assist in the transfer of promising new technology

4.3.3.3. RD&D Targets

Improving the efficiency of thermal and electrical operations is becoming increasingly important as the food industry becomes more competitive. Examples of research topics include:

- Efficient chillers, refrigerants, compressors, and other components
- Microprocessor-based monitoring/ control systems for temperature and humidity
- Efficient freezer configurations
- Improved peak load management
- Use of waste heat for cooling through heat pumps
- Renewable energy-driven cooling
- Improved facility design by improving efficient, multi-state cooling
- Temperature control in the distribution chain

4.3.4. Improvement to Food Cold Chain Management

Objective: Validate industry driven improvements

The storage and movement of food between the producer and the end user, called the “cold chain,” suffers from poor temperature management, which leads to losses in energy and food products. Cold chain includes processing, transportation, and other operations from harvest to retail to the consumer. Each product has its own temperature optimum. Systems to handle all the product temperatures in a single facility and reduce the number of temperature ranges would simplify the problem and reduce cost. The impact of cold chain improvements with fresh cut

produce, for example, could be significant. The current situation shows that improper temperature control is responsible for 27% of the products lost in retail. According to a 2003 statement of the International Institute of Refrigeration, “energy consumption of refrigerating systems could be reduced by at least 20% in the short term and an objective of 30–50% reduction, depending on applications, by 2020 is a goal which could be achieved.

4.3.4.1. Industry Identified Needs

- Develop more efficient chillers
- Improve efficiency of refrigerants and compressors
- Develop microprocessor-based monitoring and control systems for temperature and humidity
- Improve peak load management
- Use waste heat for cooling through heat pumps
- Develop solar energy driven cooling

4.3.4.2. Industry Suggested Approaches

- Improve facility design by improving efficient, multi-state cooling
- Control temperature in distribution chain
- Develop software to integrate and optimize container equipment

4.3.4.3. RD&D Targets

Refrigerated warehouses consume about 20% of the total electric energy used in the California food industry, which makes this an important area for possible PIER sponsorship.

RD&D activities in the refrigerated warehouse industry are well coordinated under the umbrella of the International Association of Refrigerated Warehouses-World Food Logistics Organization (IARW-WFLO), which makes it relatively easy to disseminate technical information gathered by RD&D projects.

Possible RD&D projects include:

- Blast freezing air velocity modulation
- Integrated hybrid refrigeration systems

4.3.5. Power Quality and Reliability

Objective: Ensure a stable and reliable source of high quality power

As the technology for managing electrical loads in food processing equipment advances, the sensitivity of food processing industries to power quality disturbances increases. Several factors have contributed to the growing importance of power quality for food processing industries:

- Microelectronic advances
- Automation increases
- Process changes from batch to continuous flow
- Electronic controls replacing electromechanical controls

- Movement of computers from the computer room to office and processing floors
- Increased cost of downtime for food processing facilities that requires continuous round-the-clock operation without maintenance

As these advances reshape the food processing industry in California, power quality concerns are becoming an important factor for productivity enhancement of California food processing industries. A food processing facility contains a number of unit processes that enable the facility to perform the work it was set up to do. These unit processes comprise industrial equipment that works with other equipment to create a system. Each individual component of the process is susceptible to power line variations. Instability in any of these sensitive devices can cause the process to fail, which can cost thousands of dollars per minute in downtime and lost product. Understanding the process is the key to mitigating these types of problems. This knowledge also allows facility engineers to work together to identify weaknesses and critical components and recommend modifications for hardening the process.

Power supply reliability is also a critical requirement for food processors. Power interruptions not only cause a tremendous loss of revenue for the processing plant and an increase in waste disposal problems, but also potentially impact food safety. Production lost due to in-season downtime might be unrecoverable. To reduce the cost of power interruption, such as in the case of an aseptic processing operation where large amounts of products must be reprocessed or destroyed as a result of power interruption, processors are opting for an uninterruptible or firm power supply of their own. They are paying the most expensive industrial electricity rates in the country to their local utility to ensure “firm” service. However, even with firm service, there are power quality aberrations that cause plant downtime and resulting food safety / quality issues.

Power quality is an electricity supply chain issue on both sides of the meter; both the utility and the customer make power quality mitigation investments. A separate Energy Commission grant awarded to Del Monte Foods (see Section V, D. Models for Strategy Implementation) funded a power quality plant assessment. From the results, the company decided to replicate the study at an additional plant. This effort created the impetus to develop a roadmap for the California food industry to develop power quality standards for monitoring and corrective action. To achieve power quality improvements as well as general energy efficiency results, modern food processing facilities will need to combine the implementation of best energy management practices with technical solutions to optimize production.

4.3.5.1. Industry Identified Needs

- Ensure consistent power quality at both the utility and its customer
- Broaden options for sources of power
- Develop more adequate uninterruptible power supplies or back up power systems

4.3.5.2. Industry Suggested Approaches

- Monitor the power quality variations at a food processing facility.
- Identify technologies and engineering solutions to mitigate power quality problems.
- Develop advanced technologies to ensure high quality power.
- Develop alternative fuels (diesel, No. 6 oil, propane, biomass, coal, etc).
- Develop co-generation

- Seek economic incentives for reducing electric load and off-peak use
- Conduct public educational and technology transfer forum

4.3.5.3. RD&D Targets

Examples of research topics include:

- Development of more reliable, powerful, and/or flexible uninterruptible power supplies or back- up power systems
- Identification of technologies and engineering solutions to mitigate power quality problems

4.3.6. Improve Water Use Efficiency

Objective: Reduce water waste and improve recycling

During the processing season, each fruit and vegetable processing plant uses on the order of 3–4 million gallons of water per day. The availability of water and the costs associated with effluent treatment are becoming major issues as resources become scarce. In some cases, water is the limiting factor in manufacturing capacity. The ability to remove and recover suspended and dissolved solids to deliver reusable or sterile water and reduce the amount of wastewater has been demonstrated. There are several examples of membrane cross-flow filtration being implemented in food processing operations to make them more energy and water efficient and to reduce wastes. Capturing low-grade thermal energy from water effluent for reuse is important, since cost benefit analyses show that minimizing heating and cooling of water and recovering the cost of waste treatment and disposal can make the industry more self-reliant.

4.3.6.1. Industry Identified Needs

- Reduce fresh water use
- Separate dissolved and suspended solids from process effluent water by incorporating separation technologies at front-end point sources (preferred) or at the end of the pipe as combined streams (much less efficient)

4.3.6.2. Industry Suggested Approaches

- Examine the benefit of redirecting processing water to bypass municipal facilities and apply treated water directly to agriculture. Must consider microbial implications and water quality standards.
- Evaluate membrane filtration technologies alone and in combination with pre- and post-treatment technologies.
- Develop more efficient membrane designs to integrate water and energy and recover valuable solids and reuse water within the plant.
- Evaluate ozonation to augment the use of chlorine for microbial control and increase feasibility of water reuse.
- Develop more versatile membrane modules for low-cost water effluent treatments that can operate under conditions of high pressure, high pH, and high solids.

- Remove and recover total suspended solids (TSS) & total dissolved solids (TDS) in process water and reuse water within the processing plant or sell residual solids as a product. Evaluate markets for these byproducts.
- Identify quality of water streams by further characterizing wash-water.
- Employ water stream segregation of dissolved and particulate solids.
- Increase investment in wastewater treatment facilities (e.g., 200,000–300,000 acre feet of water could be freed up if water bypasses municipal treatment and goes directly to agriculture or wetlands). The publicly owned treatment works could be avoided if this is a short cycle. Need to evaluate risks.
- Use methane from waste decomposition in low energy activities.
- Recover low-grade heat.

4.3.6.3. RD&D Targets

The food industry is the third largest energy user and the largest water user among the industry sectors in California. Therefore, optimizing energy and water use in food industry is of major significance to the state. Specific research topics include:

- Establish benchmarks of energy and water use and losses
- Reduce energy and water use
- Sensors and software to monitor and feedback
- System Integration
- Seasonal variation reductions

4.3.7. Reduce Supply Chain Waste between Producer and User

Objective: Develop total raw material utilization

Food processing operations can greatly improve profitability through better integration of their operations toward minimizing waste and use of such resources as energy, water, land, and air. Many manufacturers are using life cycle assessments for measuring the economics and the environmental and societal impacts of their operations, taking energy, water, and air into account in the environmental (resource) part of the analysis. Companies such as Cargill, Dow, Dupont, and Roche, to name a few, are using this approach to market their products under a sustainability label. The importance of assessing and monitoring raw material and other inputs can significantly influence profitability of the plant. Generation of energy from byproducts in-plant and through cooperatives is receiving increasing attention. The dynamics of each operation require plant-by-plant real-time assessments of specific products. Better utilization of materials--other than use in animal feed, for biomass energy, or as a waste stream--may be realized. These materials often contain useful bioactive components that are not being recovered because appropriate technologies needed for their cost-effective recovery have not yet been developed. Generalized computer models are now available to aid in these assessments but they still require refinement for a given plant operation.

4.3.7.1. Industry Identified Needs

- Re-design plant operations to minimize waste and recover byproducts

- Re-examine processes with attention to waste utilization systems approach
- Improve separations of liquid-liquid and liquid-solid streams
- Develop new uses for byproducts

4.3.7.2. Industry Suggested Approaches

- Perform life cycle analyses using various existing and new processing scenarios. Quantify energy, product, environmental, and social criteria. Use computer models.
- Determine the composition of byproduct streams and identify potential value components.
- Examine the potential for isolating, separating, or extracting food/feed components and pharmaceutical components from byproducts by highlighting functionality of co-products.
- Develop new processes and uses for byproducts.
- Integrate new and cost effective separations with applications of byproducts.
- Evaluate equipment used in processing on the basis of energy, water, and waste.
- Reduce the volume of wastes by solid-liquid separation and fractionation.
- Evaluate use of incineration for energy generation after considering all other options for re-capturing chemical energy of biomass.
- Utilize or develop new software to manage new inventory and replacements.
- Establish training and education programs.
- Demonstrate transfer of technology.
- Expand and publicize the California Integrated Waste Management Board Resource report.

4.3.7.3. RD&D Targets

Integration of components of the food system from farm to consumer and development of avenues for using byproducts reduces the costs of residue disposal and improves overall profitability. These efforts involve redesigning processes to minimize waste and recover residues that serve as a basis for new co-products. Analytical capabilities need to be developed for identification and quantification of bioactive components. A partial list of specific issues includes:

- Incineration (combustion and gasification) for energy generation
- Isolation of pharmaceutical, food, and feed components from residues
- Packaging films from cheese and tofu whey
- Recovery and utilization of tartrate from wineries
- Obtaining energy from rice straw and husks
- Integrating new and cost-effective separations with applications of byproducts
- Taking a systems approach to residue utilization
- Reducing the volume of residues
- Highlighting the functionality of co-products

- Improving separations of liquid-liquid and liquid-solid streams

4.3.8. Ensure Safety and Security of Food Supply through Changing Practices and Technologies

Objective: Evaluate the safety aspects of new technologies and develop appropriate certification technologies to ensure the safety and security of food supply

Food safety is a key issue given the global sourcing of food and ingredients and adoption of new practices and technologies in processing. Handling of food can be problematic, and the threat of bio-terrorism adds new emphasis on safety and security of food operations. Further, alarms leading to extensive market recall of product with need for subsequent reprocessing or safe disposal are expensive and wasteful. New standards are being introduced that must be evaluated and incorporated into certification programs, accounting for impacts on energy, added waste, and other resources, which could be significant. New and automated processing lines with sensors and automatic controls are being introduced (e.g., aseptic processing, pulsed electric field, high pressure processing, ultraviolet, and electron beam). Efficient removal systems for ethylene in closed environments, and replacement of certain chemicals, such as chlorine and certain refrigerants, with other more benign choices are being implemented.

4.3.8.1. Industry Identified Needs

- Integrate post-harvest treatment and management of food supply to protect it from insects, rodents, and microbial pathogens (fungi, bacteria, viruses, and parasites).
- Incorporate electronic reporting systems to catalogue levels of specific compounds in food materials at all stages in the food chain from farm to table.
- Develop system for ethylene removal. Current systems are not efficient and need to remove ethylene from the enclosed environment.
- Replace ammonia refrigerants by safer, less toxic, energy efficient alternatives.

4.3.8.2. Industry Suggested Approaches

- Integrate pest management strategies to develop disease- and insect-resistant crops so that less pesticide and herbicides are used and carried over into processing
- Develop computer software modules to track and trace pesticides and herbicides throughout process
- Evaluate the safety and security consequences of using new processing technology (e.g., aseptic, high pressure, pulsed electric field, UHT, and microwave) and sanitation agents (e.g., ozone, hot water, ultraviolet, electron beam, X-ray, and chlorine dioxide)
- Develop and validate alternative sterilization systems for operational efficiency and food safety
- Conduct educational and training sessions

4.3.8.3. RD&D Targets

Food safety is the number one issue for the food industry. Outbreaks of food-borne diseases in hamburger, fruit juices, sprouts, cheese, and ice cream are a growing concern. Changing industry practices, including sourcing of foods and food ingredients from everywhere in the world, vertically integration of operations; and development of convenience foods to replace

home-cooked meals, have resulted in a reassessment of our safeguards for assuring safe foods. A partial list of specific issues includes:

- Integrate post-harvest treatment and management of the food supply to protect it from insects, rodents, and microbial pathogens (fungi, bacteria, viruses, and parasites)
- Develop a system for ethylene removal from closed environments
- Evaluate new preservation technologies, such as coronation, ultraviolet, irradiation, hot water treatments, and controlled atmosphere, alone or in combinations
- Develop disease- and insect-resistant crops

4.3.9. Develop Seasonal Infrastructure

Objective: Address the challenges of seasonal operations

A significant part of California's food processing industry is characterized by seasonal processing varying from one to three months or less (e.g., wine, fruit and vegetable processing) to six months (e.g., nuts) as compared to year-round industries (e.g., dairy, meat, poultry). The seasonal industry is highly dependent on energy and other resources during the processing season but is often characterized by a lack of new investment in infrastructure and hardware (as is the case with dehydration of fruits). Emerging partnerships between complementary-seasonal industries is an emerging trend (e.g., ski resort and fruit/vegetable processor).

Drying of food products is an important segment of food processing that holds much potential for increasing energy efficiency with changes in practices. At present, most food operations use gas-fired heaters and electrically driven blowers for processing fruits, vegetables, nuts, and grains. Dryers and dehydrators are specialized for use with only one commodity, and the need for dehydration is seasonally linked to the harvesting of the crop. In the Central Valley, more than 3,000 tunnel dryers are in use today, mostly for the processing of grapes. The technology used is an average of 80 years old, and the cost of drying represents about 40–60% of the cost of the end product. The business is highly competitive and sensitive to cost in the global marketplace. Tunnel dryer manufacturers all make the same product, so there is little difference in the energy requirement across the industry.

4.3.9.1. Industry Identified Needs

- Ensure consistent high quality seasonal products
- Secure infrastructure that cost-effectively links energy management systems with hardware
- Improve the efficiency (while reducing the cost and attaining high-quality products) of seasonal operations
- Coordinate equipment and energy use between companies that operate at different times of the year

4.3.9.2. Industry Suggested Approaches

- Utilize more flexible equipment to extend the process season and handle a wide range of materials
- Share facilities and equipment between operations to extend season

- Link energy management with food and beverage processing
- Develop the infrastructure to link energy management systems to hardware
- Develop computer models to achieve consistent high quality product
- Share generation of power with other seasonal industries (ski resort)

4.3.9.3. RD&D Targets

Many of the California's agricultural products are available seasonally. Seasonal processing operations are usually of short duration, lasting from several weeks to several months. The capital costs for improving infrastructure for seasonal operations are difficult to justify due to low utilization. The penetration of new and more efficient technologies into the seasonal industries is slow and inadequate. A partial list of specific research topics includes:

- Optimize energy efficiency of dryers
- Utilize equipment for more than one commodity
- Adopt automatic control devices and monitoring systems
- Use lower air temperatures
- Use zone drying
- Develop standard methods and monitor results
- Use more efficient blowers and burners
- Employ solar drying and solar-assisted hot-air drying

5.0 Research and Development Opportunities and Constraints

5.1. Research Opportunities

Table 8 summarizes potential research initiatives grouped according to the needs described above.

Table 8. Comparison of industry needs and RD&D targets

Industry Needs	RD&D Targets
1. Industrial Optimization	<ul style="list-style-type: none"> • Enterprise management systems • Asset management systems
2. Technology Validation	<ul style="list-style-type: none"> • Low-quality energy recovery processes (e.g., heat pumps) • Separation technologies • Technologies to reduce energy and water use • Technologies to improve product quality and safety • Metering, sub-metering, systems overview and process simulation software • Maintenance systems and resource management • State-of-the-art electric motor technology
3. Thermal Efficiency Optimization	<ul style="list-style-type: none"> • Efficient chillers, refrigerants, compressors, and other components

	<ul style="list-style-type: none"> • Microprocessor-based monitoring/control systems for temperature and humidity • Efficient freezer configurations • Improved peak load management • Use of waste heat for cooling through heat pumps • Renewable energy-driven cooling • Improved facility design by improving efficient, multi-state cooling • Temperature control in the distribution chain • Software development to integrate and optimize container equipment.
4. Food Cold Chain Management	<ul style="list-style-type: none"> • Blast freezing air velocity modulation • Integrated hybrid refrigeration systems
5. Power Quality and Reliability	<ul style="list-style-type: none"> • Development of more reliable, powerful, and/or flexible uninterruptible power supplies or back-up power systems • Identification of technologies and engineering solutions to mitigate power quality problems
6. Improvement in Water Use Efficiency	<ul style="list-style-type: none"> • Establishment of benchmarks for energy and water use and losses • Reduction of energy and water use • Sensors and software to monitor and feedback • System Integration • Seasonal variation reductions
7. Supply Chain Waste Reduction	<ul style="list-style-type: none"> • Incineration (combustion and gasification) for energy generation • Isolation of pharmaceutical, food, and feed components from residues • Packaging films from cheese and tofu whey • Recovery and utilization of tart rate from wineries • Use of energy from rice straw and husks • Integration of new and cost effective separations with applications of byproducts • Systems approach to residue utilization • Volume reduction of residues • Highlighted functionality of co-products • Improved separations of liquid-liquid and liquid-solid streams
8. Food Supply Safety	<ul style="list-style-type: none"> • Integrate post harvest treatment and management of the food supply to assure its safety from insects, rodents and microbial pathogens (fungi, bacteria, viruses, and parasites)

	<ul style="list-style-type: none"> • Development of a system for ethylene removal from closed environments • Evaluation of new preservation technologies, such as ozonation, ultraviolet, irradiation, hot water treatments, and controlled atmosphere, alone or in combinations • Development of disease- and insect-resistant crops
9. Seasonal Infrastructure	<ul style="list-style-type: none"> • Optimization of energy efficiency of dryers • Utilization of equipment for more than one commodity • Adoption of automatic control devices and monitoring systems • Use of lower air temperatures • Use of zone drying • Development of standard methods and monitoring of results • Use of more efficient blowers and burners • Solar drying and solar assisted hot air drying

5.2. Research Constraints

Because of the great diversity in California's food industry, one-size-fits-all solutions frequently do not apply. Therefore, latitude will be required in the design of the research program to identify activities that are either broadly applicable or that respond to particularly acute situations.

Interactions in food processing plant between water and other resource use and power use can be complex in their impacts. Therefore, it is vital that research activities are carefully scrutinized to anticipate third-party impacts and possible adverse consequences. Identification of possible adverse consequences will often result in formulation of measures to minimize these consequences.

6.0 Coordinated Research Approach

The long-term well-being of California's food industry will be served by development and maintenance of a sustainable approach toward power usage. While plant managers generally have rational approaches to power use in their current facilities, improved hardware, refined strategies for hardware utilization, better coordination, and prioritization of power usage are likely to reduce power demands.

A multi-disciplinary approach is important to effective progress in the research initiatives outlined earlier in this roadmap. This type of program will enable entities to perform individual activities with the appropriate capabilities and will enable the overall program to attain a depth and breadth that could not be achieved through a more narrowly based approach.

As noted throughout this roadmap, coordination of research activities will be important to enable progress on separate yet interrelated fronts and successful translation of research results into programs ready for implementation. An additional important research activity will be the monitoring and evaluation of project implementation and operation so that these experiences can be applied to refining ongoing and future projects.

Central to the functioning of the research program will be an organization that will serve as a program manager. This entity will help establish benchmark parameters, assess research priorities, identify funds, and match these funds with entities competent to carry out the research. Beyond the RD&D responsibilities, the program manager can identify the process to develop and promote best energy management practices and screening.

In addition, the program manager will be central to guiding research through the series of stages identified below and illustrated in Figure 5.

- Conceptual research
- Production
- Implementation
- Feedback and refinement

The program manager will be involved in framing conceptual research ideas and reviewing research results. In instances where prototype results are promising, the program manager may be active in identifying how to transform research or prototype results into production-level hardware or software. Implementation and installation of production-level tools generated from research will probably require little input from the program manager, but the manager will likely be involved in the monitoring and evaluation of field installations to provide feedback to the research process.

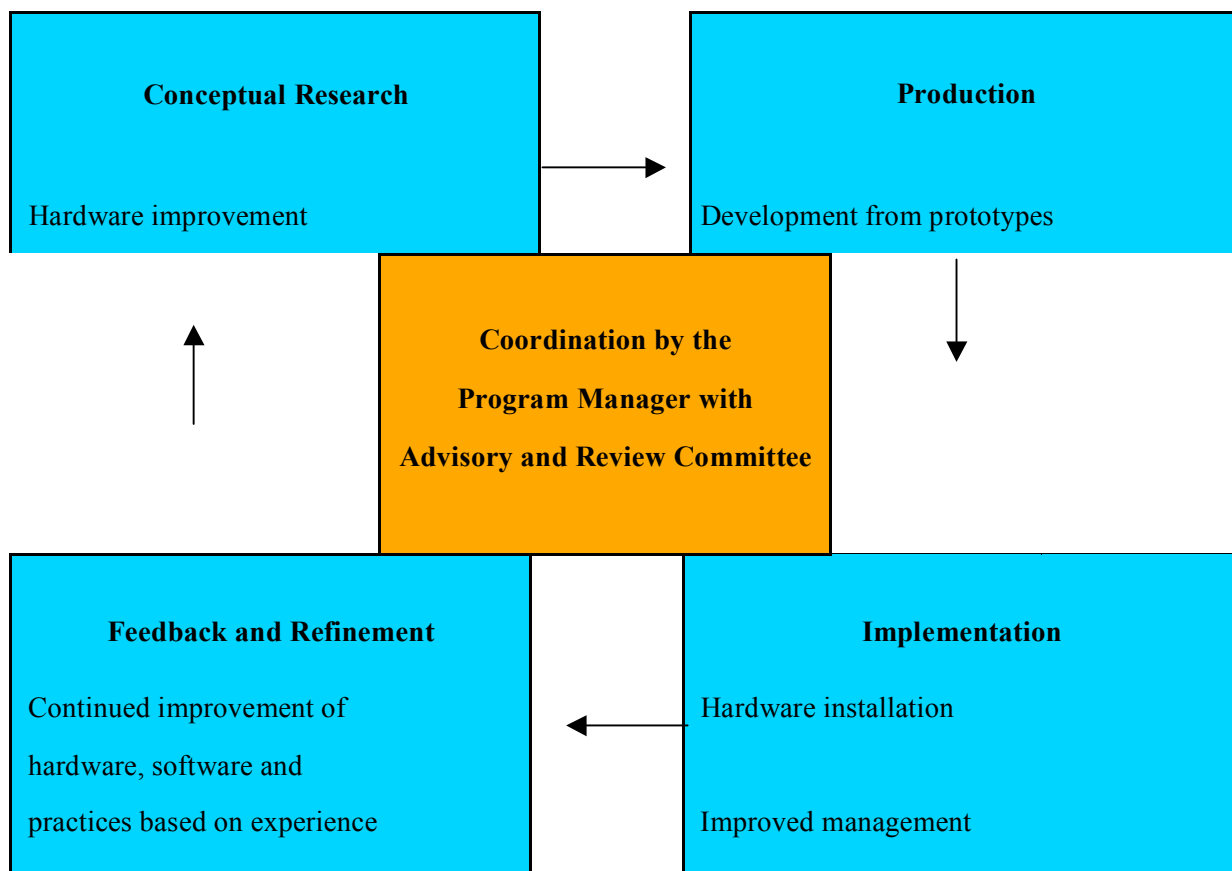


Figure 5. Schematic illustration of the role of the program manager

Figure 6 illustrates constraints or considerations that will come into play at different stages in the cycle of research and implementation.

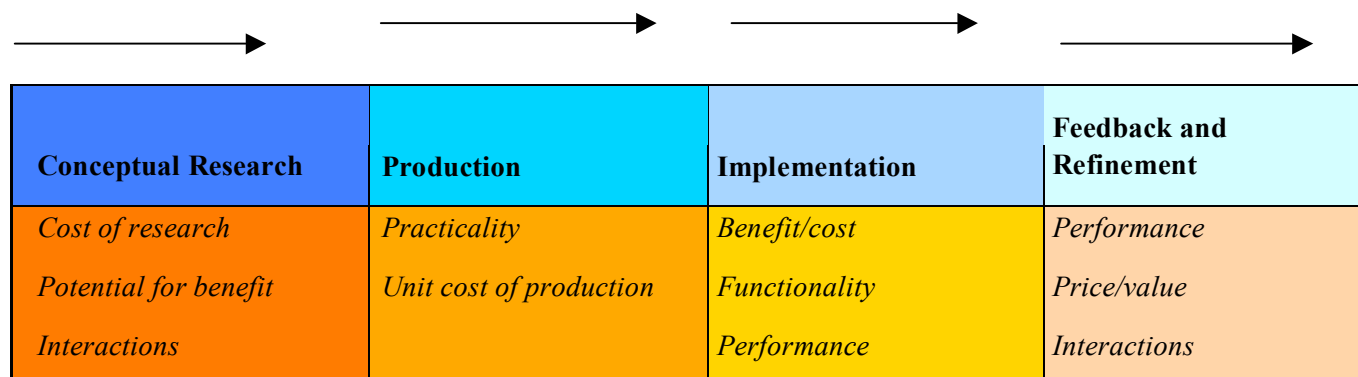


Figure 6. The RD&D Conceptual Process

At this time, it appears that the following types of organizations are likely to be involved in the research program:

- Universities and research institutions
- Hardware and software manufacturers
- Food industry companies
- Electric utilities
- State, local, and federal agencies

The program manager will coordinate activities among entities participating in research, development, and implementation to formulate a development pipeline for conceptual research ideas. The development pipeline can expedite the implementation of successful research programs and minimize the likelihood of successful research being stranded due to its isolated evolution. The program manager will also seek to avoid duplication of work that is already funded by other sources.

Because the development horizon for research initiatives varies, important research activities will be categorized by both their priority (potential significance) and the projected time for their development (near term, medium term, long term). The objective of this screening will be to direct funding toward projects having high or medium potential significance and with a range of development horizons. Thus, medium potential projects with short development schedules could be combined with higher potential projects requiring greater time to assemble a program that generated near-term results while supporting more ambitious long-term objectives.

7.0 Conclusions and Recommendations

The roadmap agenda provides the basis for soliciting and evaluating proposals that will significantly impact energy and water efficiencies and such important factors as waste minimization in California's food processing industry. The economic strength of the industry will be determined by its ability to optimize production, reduce waste, and increase the

productivity of utilized resources. Overall plant efficiency can be enhanced by optimizing the use of the energy resources as the foundation for total plant improvements.

The first round of proposals received and awarded according to the research needs and priorities identified in this document is outlined in Appendices E and F.

7.1. Recommendations

- Distribute the roadmap to the California food industry.
- Using the roadmap as a base, provide assessments on the potential of energy and water efficient technologies to specific food processing operations as requested. Establish a Center of Excellence in Energy and Water Efficiency to centralize demonstration and transfer of technologies.
- Support CEC, CDFA, and specific California food processing industry organizations with technical assistance as needed.
- Host public forums to disseminate and further discuss results of funded research.
- Publish and otherwise disseminate information on technology, which if implemented could mean significant savings in energy and water use and provide an environmentally sound direction.

7.2. Benefits to California

Outcomes of research projects will be shared and serve as a model for food processors to adapt to their own situations to improve production efficiencies and thereby enhance competitiveness of industry in California.

Research projects will provide energy and environmental benefits without direct costs to the industry partners (PIER program providing funding). See benefits, in terms of possible energy savings from implementation of the nine PIER-funded projects, as summarized in Appendix E.

7.3. Commercialization Potential and Examples

7.3.1. Dehydrators (addresses need to optimize equipment and utilities and improve thermal efficiencies)

In one project, FIAC member Walter King found that refinements to dehydration tunnels could significantly reduce use of natural gas. In a large raisin dehydration plant, King found that redirecting air, reducing fan speed, and measuring and controlling moisture for optimal recirculation resulted in a 35% reduction in electrical use and a 10%–20% reduction in natural gas use. With energy incentives for up to 50% of costs, payback for modifications was 25 days (gas) and 50 days (electrical).

7.3.2. Forklifts (addresses need to optimize equipment and utilities)

Two currently funded projects address energy efficient optimization for operation and maintenance of forklifts in a manufacturing plant setting. Specifically, Del Monte Foods is testing new technology at their Modesto (STAC grant) and Hanford (EPRI grant) plants.

The plant at Modesto will be part of the STAC demonstration project to monitor real-time forklift energy activity via Internet in enterprise energy management (EEM). This project will evaluate new AC forklift and fast charging technologies. Del Monte Foods is one of the first U.S.

manufacturers to implement this advanced technology. EEM will be coupled with enterprise asset management (EAM), where EEM energy data feeds EAM as an input for predictive and preventive maintenance to ensure the equipment is maintained and operated in an energy efficient manner. Working capital investment for parts is minimized as well as labor man-hours.

The plant at Hanford will compare propane and AC vs. DC voltage to fast-charge forklifts. They are currently in year two of this four-year project, and still to be done is photovoltaic charging on peak as well as AC forklift flow batteries and fuel cell development. The results are expected to significantly increase fuel efficiency and optimize forklift performance and maintenance.

7.3.3. In-plant Wastewater Treatment (addresses need to improve water use efficiency and reduce supply chain waste)

Professor Ruihong Zhang, with funding from the California Energy Commission, will be demonstrating waste conversion and wastewater treatment technologies using a solids digester system. Her patent-protected integrated wastewater treatment technology will be used at pilot scale on the campus of the University of California, Davis, and at commercial scale at the City of Industry to demonstrate digestion of green and food wastes. The pilot digester is expected to process 3 tons of waste per day beginning in late 2004. Additional wastewater digester systems will be used to treat various wastewater streams, including meat processing wastewater. A new anaerobic digester, called anaerobic mixed biofilm reactor, has been shown to work well for treating wastewater and is being applied to wastewater from Gills Onions and Norcal Waste Systems.

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9.0 Glossary

Biomonitoring is a measure of living biological organisms or parts thereof.

BOD, Biological Oxygen Demand : The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time under specified conditions; usually specified as milligrams of oxygen used per liter of effluent at 20°C in a five-day period.

Byproduct is a side product made during the manufacture of something else.

COD, Chemical Oxygen Demand: The quantity of oxygen used in biological and non-biological oxidation of materials in water; a measure of water quality.

Co-product is a product produced together with another product.

Effluent Water: Water that flows out of a processing plant, sewer, or industrial outfall. Generally refers to wastes discharged into municipal treatment plants or on-site evaporation ponds.

Firm power supply refers to uninterruptible power.

Kilowatt-hour (kWh) - a measure of electrical energy.

Public Interest Energy Research (PIER) supports public interest energy research, development and demonstration (RD&D) that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace. The PIER Program annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with RD&D organizations including individuals, businesses, utilities, and public or private research institutions.

Power Quality refers to any occurrence manifested in voltage, current, or frequency deviations that results in failure or misoperation of industrial plant equipment. May occur inside or outside of the metered circuit.

Power Reliability: The more frequent the loss of power the lower the reliability.

10.0 Acronyms

ARW - The International Association of Public Refrigerated Warehouses

ASERTTI - Association of State Energy Research and Technology Transfer Institutions

CDFA - California Department of Food and Agriculture

CEC - California Energy Commission

CLFP - California League of Food Processors

EAM - Enterprise Energy and Asset Management

EEM - Enterprise Energy Management

EPRI – Electric Power Research Institute

DOE - Department of Energy

IFPA - International Fresh-cut Produce Association
LBNL - Lawrence Berkeley National Laboratory
NASEO - National Association of State Energy Officials
NFPA - National Food Processors Association
NWFPA - Northwest Food Processors Association
PG&E - Pacific Gas and Electric Company
RD&D - Research, Development and Demonstration
SKU - Stock Keeping Unit
STAC - State Technologies Advancement Collaborative
WFLO - World Food Logistics Organization
WSU - Washington State University

Appendix A

California's Food Processing Industry Review (SIC 20)

Prepared by Catherine M. Sullivan, California Energy Commission

The food processing industry (SIC 20) consists of companies that manufacture or process meat products, dairy products, canned and preserved fruit and vegetables, grain mill products, bakery products, sugar and confectionery products, fats and oils, beverages and miscellaneous food preparations (canned fish, coffee, salty snacks, ice and macaroni).

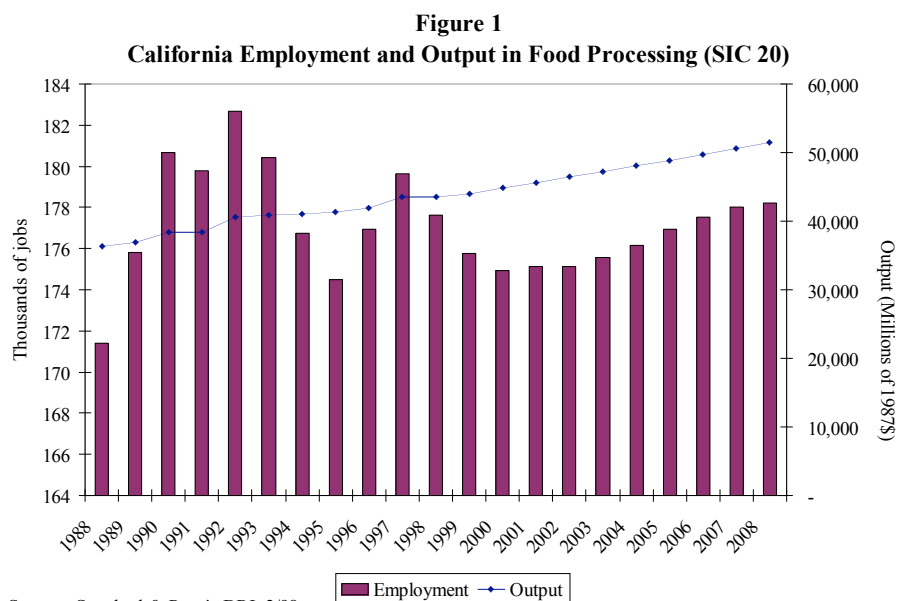
California's total food processing output, defined in this analysis as the total value of shipments, was \$41.8 billion dollars in 1996. California's food processing industry leads the U.S., a position California has held for the last half-century. In 1996, the state accounted for more than 10 percent of U.S. food processing output. California accounts for more than 20 percent of national output in the preserved fruit and vegetable industry and 18 percent of U.S. output in the beverage industry. California's output is 10 percent or greater than the nation in three other sectors: bakery products, sugar and confectionery products and miscellaneous food preparations.

Table 1
Food Processing Output for California and the U.S. (1996)

SIC	Description	California Output	U.S. Output	CA/US
		<u>(Millions 1987 \$)</u>	<u>(Millions 1987 \$)</u>	<u>Share</u>
201	Meat Products	3,576	93,670	3.8%
202	Dairy Products	4,081	45,368	9.0%
203	Preserved Fruit & Vegetables	8,800	41,342	21.3%
204	Grain Mill Products	2,863	42,007	6.8%
205	Bakery Products	2,933	27,129	10.8%
206	Sugar & Confectionery Products	2,489	21,552	11.6%
207	Fats & Oils	1,348	18,429	7.3%
208	Beverages	11,351	61,226	18.5%
209	Misc. Food & Kindred Products	<u>4,417</u>	<u>33,914</u>	<u>13.0%</u>

Source: Standard & Poor's DRI, 2/98

This review concentrates on the economics of the food processing industry, particularly on its growth, employment and energy use. The discussion begins with an industry overview, and then focuses on individual sectors. Recent data and forecasts indicate this California industry is characterized by slow employment growth, modest output growth and rising energy use.



Source: Standard & Poor's DRI, 2/98

Figure 1 shows historic and forecasted employment and shipments in California. Historical employment is cyclical since the industry is dependent on weather and crop yields. Employment is forecast to improve a modest 0.3 percent from 1998 to 2008 despite the decline in employment through 2000. However, the value of shipments (in 1987 dollars) has increased 1.46 percent annually from 1998 to 1997 and is forecast to increase 1.69 percent annually through 2008. Output is expected to increase because of improved labor productivity, increased competition among food processors and growth in the state's population. Mergers and acquisitions normally affect this industry's employment because of layoffs and plant closures. The sectors hit the hardest by mergers and acquisitions from 1990 to 1997 are preserved fruit and vegetables and fat and oil products.

Table 2 shows 1996 three digit SIC data for California's food processing industry. More than 25 percent of the industry's output is produced by the beverage industry, which also has the largest number of establishments and the second highest employment. Of these establishments, 62 percent are in California's wine business. The canned and preserved fruit and vegetable sector also produces more than 20 percent of total industry output and has the most employment of any food processing sector. The large share of output is primarily due to California's extensive fruit and vegetable crops.

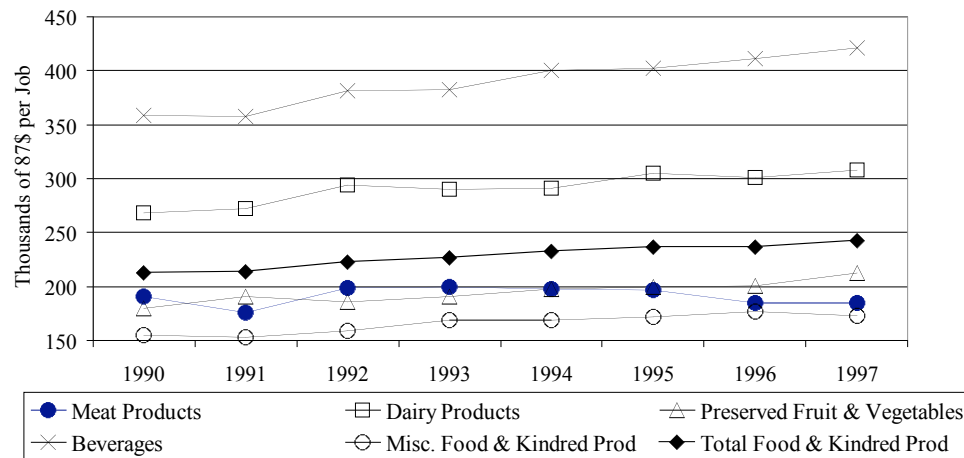
Table 2

10.1.1. 1996 California Food Processing Industry

<u>SIC</u>	<u>Description</u>	<u>Establishments</u>	10.1.1.1. obs	Calif. Output (Millions \$1987)	Share of 10.1.1.2. C alif. Output
201	Meat Products	230	17,734	3,576	8.5%
202	Dairy Products	203	13,503	4,081	9.8%
203	Preserved Fruit & Vegetables	541	47,030	8,800	21.0%
204	Grain Mill Products	212	7,907	2,863	6.8%
205	Bakery Products	635	22,974	2,933	7.0%
206	Sugar & Confectionery Products	164	10,591	2,489	6.0%
207	Fats & Oils	65	2,424	1,348	3.2%
208	Beverages	662	31,927	11,351	27.1%
209	Misc. Food & Kindred Products	<u>591</u>	<u>22,016</u>	<u>4,417</u>	<u>10.6%</u>
	Total Food & Kindred Products	3,303	176,106	41,858	100.0%

Source: California Trade and Commerce Agency, Standard & Poor's DRI, 2/98

Figure 2
California Food Products Output per Job



Standard & Poor's DRI 2/98

Labor productivity, as measured by output per employee, improved in each sector except meat products from 1990 to 1997. Increasing labor productivity is the result of investment in new equipment and plants. Also, corporate merger activity and increased competition has resulted in the closure of older, smaller and less productive facilities. This trend is expected to continue throughout the food processing industry, though not equally among all sectors. Figure 2 shows California output per employee for five selected food processing sectors. Compared to overall industry labor productivity, output per job is higher in beverages (74 percent) and dairy products (27 percent). The rate of productivity growth in these two sectors is 2.3 and 2.0 percent per year, slightly greater than the 1.9 percent per year growth in productivity for the entire industry. Although productivity in meat products is somewhat lower than the entire industry, output per job was 3.5 percent lower in 1997 than in 1990.

Food processing companies convert raw agricultural output into food products that are easily transported and stored and have a longer shelf life. Process energy is used for washing, cooling, freezing, cooking, dehydrating and canning. In 1996, California food processors used 11.3 percent of the electricity consumed by industrial customers. Figure 3 shows 1997 electric and natural gas consumption in the California food processing industry by individual sector. Preserved fruit and vegetables (SIC 203), dairy products (SIC 202) and beverages (SIC 208) account for 58 percent of the electricity use in food processing. Preserved fruit and vegetables alone account for 44 percent of the natural gas used in the industry. This large amount of energy use in one sector of the industry is due to the energy intensity of canning, dehydration and freezing.

Figure 3
1997 Electricity and Natural Gas Consumption
by Food Processing Industry

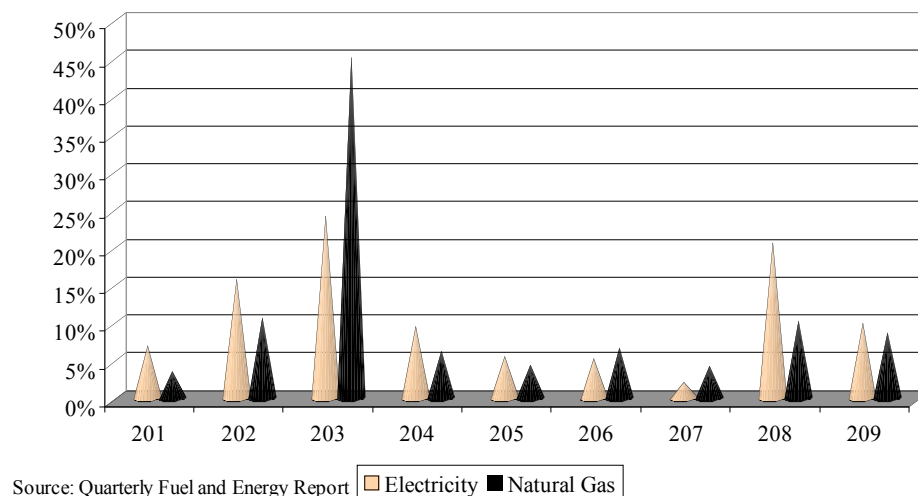


Table 3 shows the growth in real output, electricity use and natural gas use for individual industries. For the entire industry, electricity usage has grown faster than real output, whereas natural gas use has declined. For seven out of nine sectors within the industry, growth in electricity use outstripped growth in real output. However, only in grain mill products has natural gas usage grown faster than real output and in five sectors, gas use has declined. The largest decline in energy usage is in sugar and confectionery products. The three industries identified in Figure 2 as large energy users are each a little different. In the preserved fruits and vegetables sector, the data shows that electricity and natural gas use are both rising more slowly than output. In the beverages and dairy products industries, electricity use is rising much faster than output, whereas gas use is rising more slowly (beverages) or declining (dairy products).

Table 3
Rates of Growth of Outout and Energv Use (1990-1997)

S	Description	Real Outout	Electricity Use	Natural Gas Use
201	Meat Products	-0.19%	0.10%	-1.42%
202	Dairv Products	1.95%	3.68%	-5.93%
203	Canned & Preserved Fruit & Vegetables	1.65%	1.28%	0.36%
204	Grain Mill Products	-0.53%	1.57%	0.61%
205	Bakerv Products	1.84%	2.73%	-0.93%
206	Sugar & Confectionerv Products	0.81%	-0.40%	-11.49%
207	Fats & Oils	2.53%	2.58%	0.71%
208	Beverages	3.51%	6.29%	1.06%
209	Misc. Food & Kindred Products	1.64%	3.24%	-5.43%
20	Total Food & Kindred Products	1.90%	2.68%	-1.55%

Source: Standard & Poor's DRI, Quarterly Fuel and Energy Report (QFER)

Meat Products (SIC 201)

The meat products sector includes processing of beef, pork, poultry, sausages and other prepared products. The industry is heavily dependent on weather, costs of feed and demand for meat products. In the past decade, the demand for red meat has declined and demand for poultry has steadily increased because of health concerns about cholesterol intake.

Table 4 shows electricity and natural gas usage, number of establishments and jobs in the meat products industry. The meat products industry uses about seven percent of total food processing industry electricity and 3.5 percent of the total natural gas. Electricity and natural gas use per establishment is slightly higher for poultry slaughtering and processing plants compared to meat packing plants. If consumers continue to substitute poultry for beef (the forecast projects the share of poultry processing to rise from 1998 to 2008 from 28 percent to 35 percent), electricity use in the meat products industry should gradually increase.

Table 4

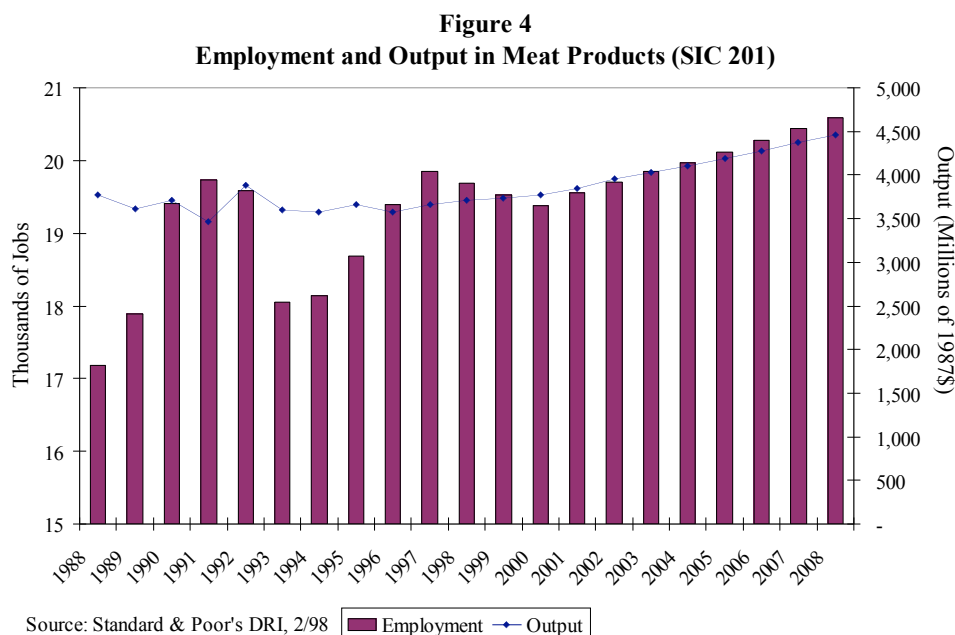
California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

Meat Products Industry

SIC	<u>Description</u>	Electricity	Natural Gas	Establis	<u>Jobs</u>
		<u>(million KWh)</u>	<u>(million therms)</u>	<u>ments</u>	
201 1	Meat Packing Plants	159.8	8.0	61	3,708
201 3	Sausages and Other Prepared Products	95.5	3.7	125	4,135
201 5	Poultry Slaughtering and Processing	134.7	10.7	44	9,891

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 4 shows employment and output for meat products. Before 1998, employment was variable but output was relatively constant because output and employment in beef processing fell as poultry processing output increased. From 1988 to 1998, output of poultry products doubled. After 1998, employment in the industry is expected to increase 0.5 percent per year and output 2.1 percent per year. Beef and pork processing has had very low profit margins, about .7 to 1.5 % over the last decade,



suggesting that only the most efficient companies will continue (Standard and Poor's, 1998).

Dairy Products (SIC 202)

Individual sectors within the dairy products industry include butter, cheese products, frozen desserts and fluid milk. California is a leading producer of dairy products, with nine percent of U.S. dairy output coming from California. In the early 1980's, dairy farmers in California expanded their production capacity and efficiency by establishing new dairy farms and new processing plants. Nationally, the last decade has witnessed a 20.8 percent decline in the number of firms in the industry due to mergers and acquisitions and closures of older plants (Standard and Poor's, 1998).

In California, the fluid milk sector uses the most electricity and natural gas, and has the most companies and jobs within the dairy products industry. The large amount of energy used in fluid milk production is due to refrigeration requirements, pasteurization and the large number of plants (Table 5). About 58 percent of all California dairy industry jobs are in the fluid milk sector. Employment within the fluid milk industry has fallen in recent years, due to improved efficiency and consolidation. Since consumption levels per person do not change much over time, demand for fluid milk should rise at the rate of population growth. The U.S. cheese industry has steadily increased employment because of rising demand for cheese products.

Table 5

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

Dairy Products Industry

SIC	<u>Description</u>	<u>Electricity</u> <u>(million KWh)</u>	<u>Natural Gas</u> <u>(million</u> <u>therms)</u>	<u>Establish</u> <u>ments</u>	<u>Jobs</u>
202 1	Creamery Butter	*	*	*	*
202 2	Cheese, Natural and Processed	250.0	21.1	51	2,724
202 3	Dry, Condensed and Evaporated Prod	96.7	4.9	19	847
202 4	Ice Cream and Frozen Desserts	171.7	1.6	58	2,073
202 6	Fluid Milk	363.0	33.5	74	7,859

* Confidentiality agreements do not allow public release of energy data in industries with less than 10 utility accounts.

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 5
Employment and Output in Dairy Products (SIC 202)

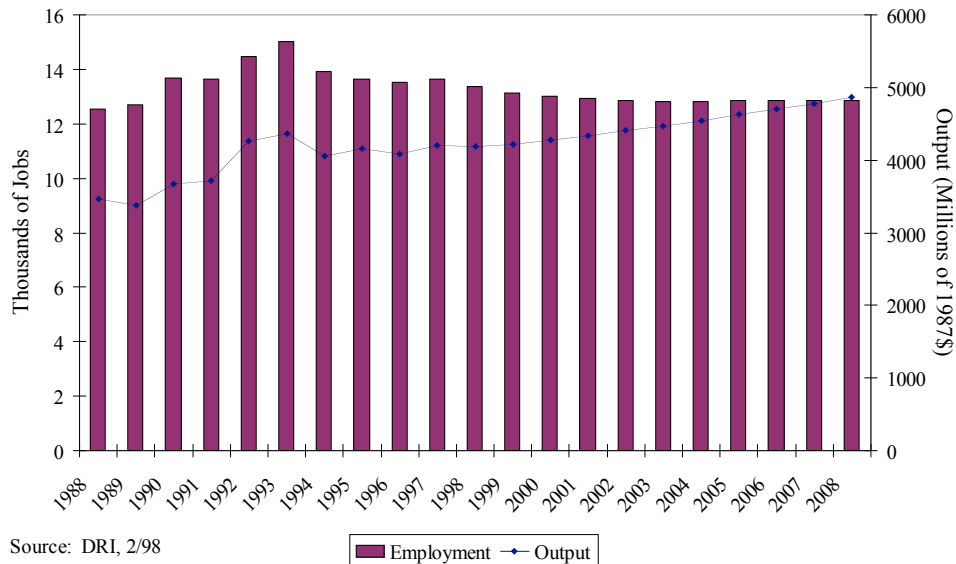


Figure 5 shows that the value of output rose 1.9 percent per year from 1988 to 1998, and employment was up 0.6 percent per year. However, employment has been falling since 1993. From 1998 to 2008, employment is expected to decrease 0.4 percent per year while output is expected to increase 1.7 percent per year.

Preserved Fruit and Vegetables (SIC 203)

Businesses in this sector produce several different types of fruit and vegetable products that are canned, dehydrated or frozen. Table 7 shows that the largest sector in terms of shipments is canned fruits and vegetables (SIC 2033). While there has been a decline in consumption of canned fruits and vegetables, the industry also includes catsup, pizza sauce and salsa, whose consumption has been growing in recent years.

The heaviest concentration of fruit and vegetable processors is in California. For example, California produces approximately 90% of the U.S. output of processed tomato products. There has been a significant drop in the number of fruit and vegetable canneries, except for firms producing catsup and other tomato products. California has also experienced a significant drop in establishments freezing vegetables because the operations have been moved to Mexico.

Table 6 shows electricity use, natural gas use, number of establishments and jobs in the preserved fruit and vegetables industry. The sector with the largest energy use, the most establishments and 41 percent of all employment in the industry is canned fruit and vegetables. This is a major California industry because of the state's strong agricultural base.

Table 6

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

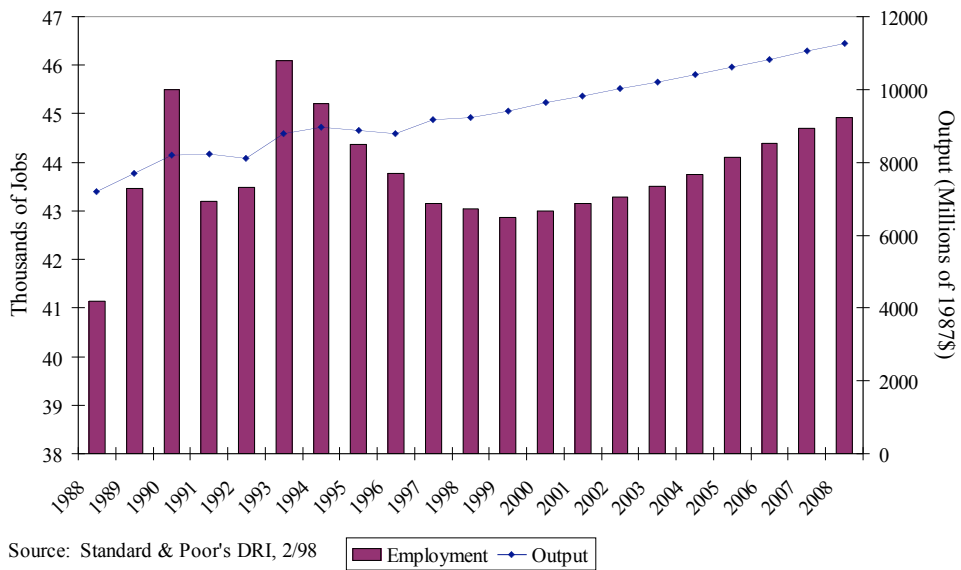
Preserved Fruits and Vegetables Industry

SIC	Description	Electricity (million KWh)	Natural Gas (million therms)	Establish ments	Jobs
203 2	Canned Specialties	72.8	9.9	28	3,417
203 3	Canned Fruits and Vegetables	550.2	171.4	173	19,446
203 4	Dehydrated Fruits, Vegetables & Soups	268.2	60.2	154	8,925
203 5	Pickles, Sauces and Salad Dressing	30.2	2.4	66	2,536
203 7	Frozen Fruits and Vegetables	329.8	38.7	48	6,722
203 8	Frozen Specialties	105.1	3.5	72	5,984

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 6 shows a modest increase in employment of 0.5 percent per year and a 2.5 percent per year increase in output from 1988 to 1998. Through 2008, employment is expected to continue to increase at 0.5 percent per year while output growth slows down to 2.2 percent per year.

Figure 6
Employment and Output in Preserved Fruit and Vegetables (SIC 203)



Grain Mill Products (SIC 204)

This sector includes grain mill products, cereal, flour, corn and rice milling, pet food and prepared feeds. Grain mill products constitute 6.8 percent of California food processing output. The largest end user of grains is the livestock sector, accounting for about 59 percent of the market.

Table 7 shows electricity use, natural gas use, number of establishments and jobs in the grain mill products industry. The largest electricity and natural gas user is prepared feeds. Flour and other grain mill products use the largest amount of electricity. However, prepared feeds (SIC 2048) has the largest number of establishments. Businesses in this sector produce feed for farm and ranch animals, such as cows, horses and pigs.

Table 7

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

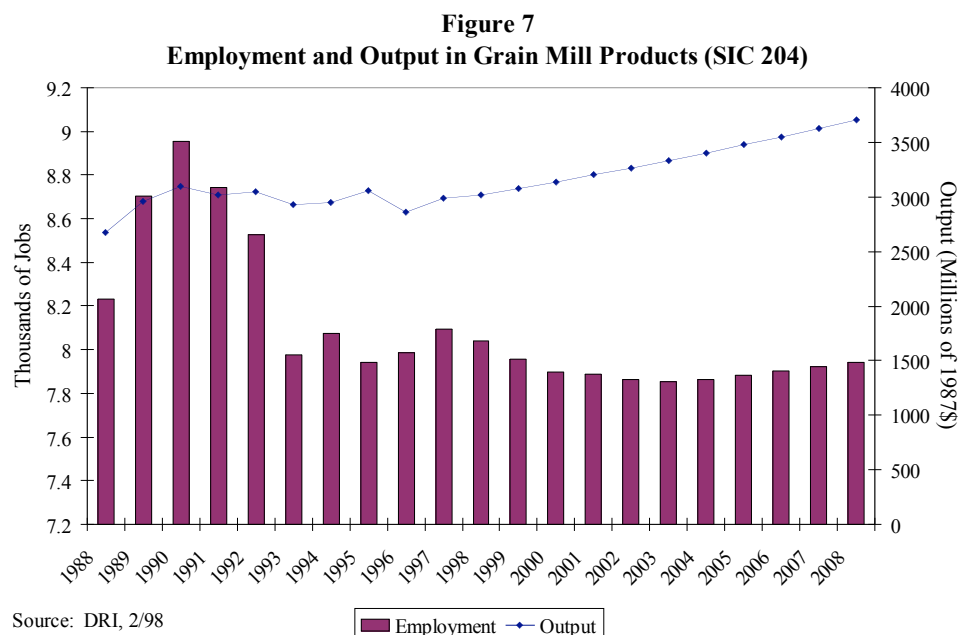
Grain Mill Products

SIC	<u>Description</u>	<u>Electricity</u> <u>(million KWh)</u>	<u>Natural Gas</u> <u>(million</u> <u>therms)</u>	<u>Establish</u> <u>ments</u>	<u>Jobs</u>
204 1	Flour and Other Grain Mill Products	131.4	1.7	27	841
204 3	Cereal Breakfast Foods	70.2	6.2	12	1,083
204 4	Rice Milling	87.7	1.1	19	1,188
204 5	Prepared Flour Mixes and Doughs	8.8	*	23	846
204 6	Wet Corn Milling	*	*	5	*
204 7	Dog and Cat Food	49.5	8.3	20	1,719
204 8	Prepared Feeds, NEC	117.1	17.2	106	*

* Confidentiality agreements do not allow public release of energy data in industries with less than 10 utility accounts.

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 7 shows that while output has remained steady, employment in the industry dropped in the first part of the 1990's. After 1997, employment is forecast to decline 0.1 percent per year through 2008 and



output is expected to increase 2.3 percent per year.

Bakery Products (SIC 205)

The bakery products industry consists of establishments involved in producing and processing bread and bakery products such as bread, cake, cookies and crackers and frozen bakery products. California is also a leading shipper of bakery products to other states. Except for beverages, the number of establishments in this industry exceeds that of any other food processing industry.

Traditionally, the bakery products industry has been split into three sectors: wholesale, retail and in-store sales. Wholesale bakers supply retail outlets. Retail outlets sell their own products along with goods purchased from wholesale bakeries. In-store bakeries are part of a large retail establishment, like a grocery store. The number of in-store bakeries grew 85% from 1985 to 1989, reflecting the addition of in-store bakeries in membership warehouse clubs (EPRI, 1994). Since 1990, mergers and acquisitions are the major causes for a 58 percent decline in the number of establishments in the industry.

Table 8 presents the electricity use, natural gas use, number of establishments and jobs in the bakery products industry. The businesses in bread, cake and related products (SIC 2051) have 85 percent of all bakery establishments, 81 percent of all jobs in bakery products and use 68 percent of the electricity. The prominence of this segment of the industry within bakery products is not expected to change.

Table 8

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

Bakery Products

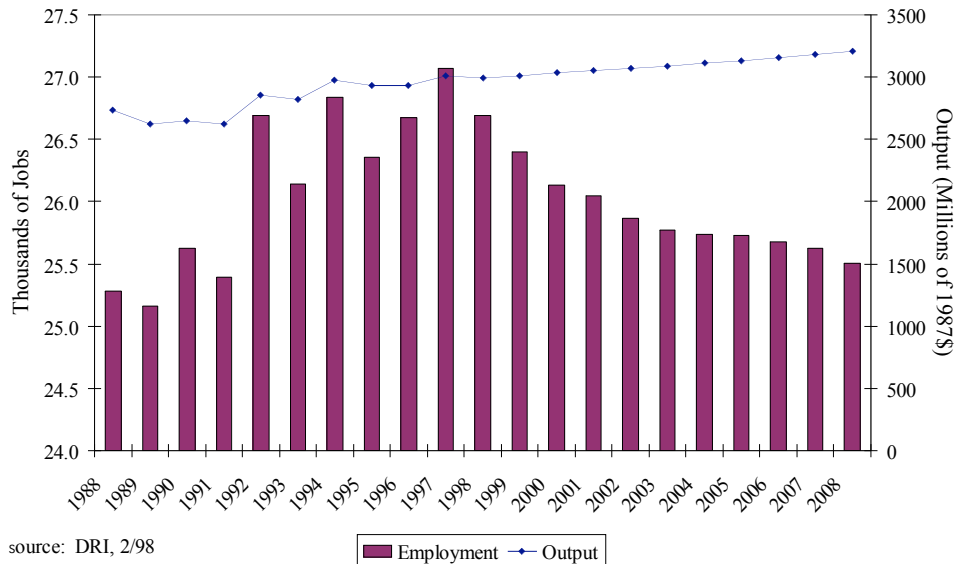
SIC	<u>Description</u>	Electricity <u>(million KWh)</u>	Natural Gas <u>(million therms)</u>	Establish <u>Ments</u>	<u>Jobs</u>
205 1	Bread, Cake and Related Products	211.9	22.9	541	18,618
205 2	Cookies and Crackers	39.7	4.9	73	3,217
205 3	Frozen Bakery Products, exc. Bread	54.1	*	21	1,139

* Confidentiality agreements do not allow public release of energy data in industries with less than 10 utility accounts.

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Productivity (output per employee) increased 14% from 1977 to 1986 (EPRI, 1994). As competition for market share compels industry participants to continue cutting margins, there will be industry-wide pressure for continued productivity improvements. Employment is forecast to decline by 0.5 percent per year from 1998 to 2008, with output anticipated to rise 0.8 percent per year (Figure 8).

Figure 8
Employment and Output in Bakery Products (SIC 205)



Sugar and Confectionery Products (SIC 206)

The sugar and confectionery industry consists of establishments involved in the manufacture and sale of raw and refined sugar, chocolate and non-chocolate candy, chewing gum, nuts and seeds. While the consumer trend towards healthy foods has affected almost all food product industries, it appears to have had little impact on the confectionery products industry. One explanation is that there are few healthy substitutes for candy, confectionery products or chocolate. In 1987, four of the top ten SIC 206 companies were mainly involved in refining cane sugar. California has more SIC 206 companies than any other state (EPRI 1991).

Table 9 shows the highest ratio of employees per establishment is in sugar related businesses. Sugar cane refining establishments average 156 jobs per firm and beet sugar producers average 178 jobs. The highest electricity use is in chocolate and cocoa products, indicating that the process of converting cocoa beans to cocoa is highly energy intensive. The largest natural gas user is beet sugar, which also uses 28 percent of the industry's total electricity (including those sectors for which data cannot be disclosed). The chocolate and cocoa sector has the largest number of companies and employees.

Table 9

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

Sugar and Confectionery Products

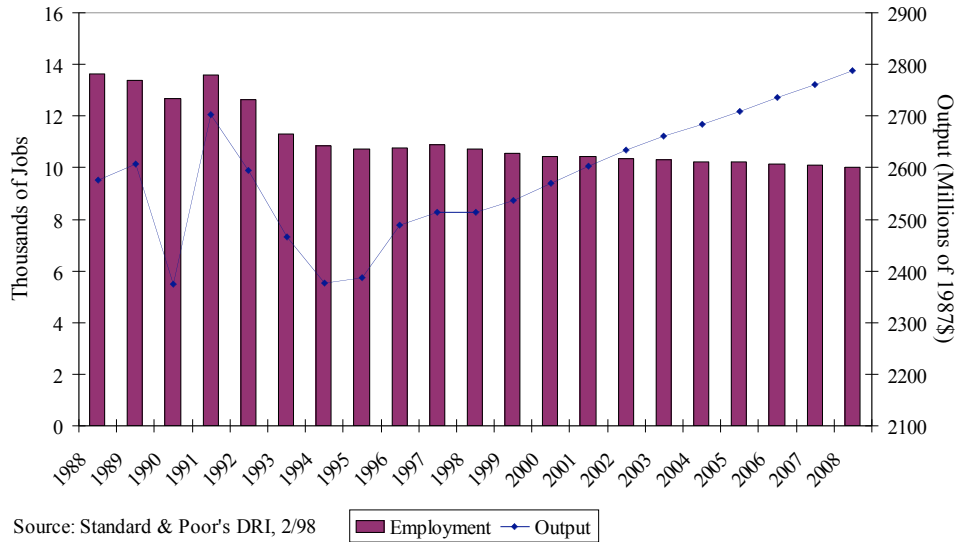
SIC	Description	Electricity (<u>million KWh</u>)	Natural Gas (<u>million therms</u>)	Establish <u>ments</u>	<u>Jobs</u>
206 1	Raw Cane Sugar	*	*	1	*
206 2	Cane Sugar Refining	*	*	4	625
206 3	Beet Sugar	82.2	33.2	7	1,250
206 4	Candy and Other Confectionery Prod	32.9	2.7	106	3,796
206 6	Chocolate and Cocoa Products	91.3	2.7	16	1,570
206 7	Chewing Gum	*	*	2	*
206 8	Salted and Roasted Nuts and Seeds	20.7	1.4	28	2,806

* Confidentiality agreements do not allow public release of energy data in industries with less than 10 utility accounts.

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Employment historically has been gradually going down, while output has been variable. From 1998 to 2008, employment is expected to continue to decline at 0.8 percent per year, while output is expected to rise 1.2 percent per year (Figure 9).

Figure 9
Employment and Output in Sugar and Confectionery Prod (SIC 206)



Fat and Oil Products (SIC 207)

Establishments in SIC 207 produce fats and oils from oilseeds, animal products and vegetables. Because transportation costs can represent as much as five to ten percent of production costs, fat and oil refineries tend to be located in the Midwest, nearest to the growing regions for key raw materials.

In California, fats and oils is the smallest sector within the food processing industry group, accounting for 3.2 percent of shipments in 1996. Although soybean oil mills are predominant nationally, California has more cottonseed oil mills than soybean and vegetable oil mills combined. Nationally, the edible fats and oils group accounts for 28% of shipments in SIC 207, but this could increase because consumer demand is shifting to oils low in saturated fats and with lower caloric content.

Table 10 presents electricity use, natural gas use, number of establishments and jobs. Over 90 percent of this industry's electricity and natural gas usage is in edible fats and oils and in animal and marine fats and oils. These two sectors also have the largest number of jobs in fat and oil products.

Table 10

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

Fats and Oils

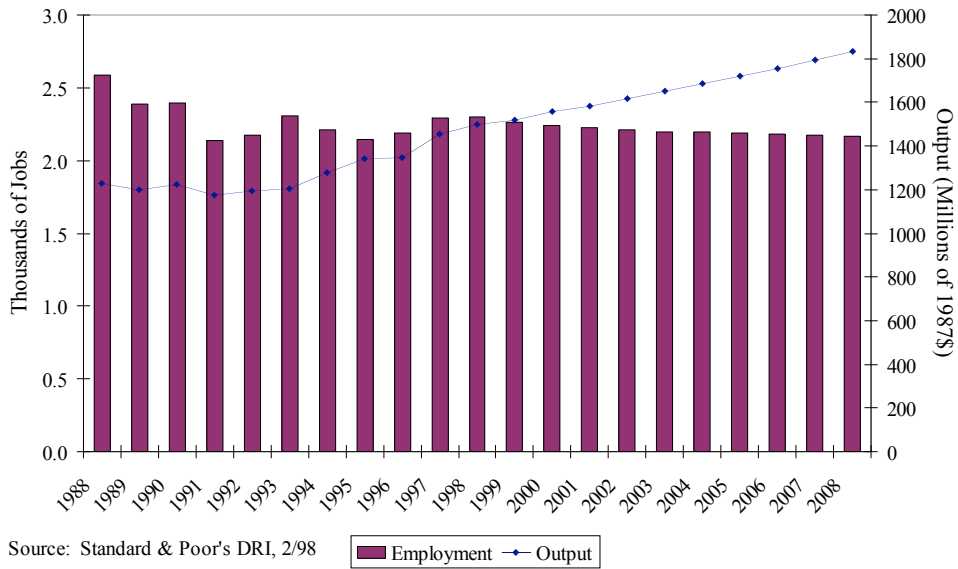
SIC	<u>Description</u>	Electricity <u>(million KWh)</u>	Natural Gas <u>(million therms)</u>	Establish <u>ments</u>	<u>Jobs</u>
207 4	Cottonseed Oil Mills	10.9	*	16	567
207 5	Soybean Oil Mills	2.2	*	7	195
207 6	Vegetable Oil Mills	*	1.7	6	171
207 7	Animal and Marine Fats and Oils	39.2	18.5	15	700
207 9	Edible Fats and Oils	58.6	4.2	21	791

* Confidentiality agreements do not allow public release of energy data in industries with less than 10 utility accounts.

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 10 shows steady employment and increasing output through 1997. From 1998 until 2008, employment is forecast to decrease 0.6 percent per year and output is expected to rise by 2.3 percent per year.

Figure10
Employment and Output in Fats and Oils (SIC 207)



Beverages (SIC 208)

Beverages include alcohol, soft drinks, and flavorings. Alcoholic beverages are the largest energy user and have the most establishments and employees in California. The alcoholic beverage industry has three distinct sectors: malt beverages, wines and brandy and distilled spirits. Between 1989 and 1995, the amount of malt beverages produced nationally declined 0.4 percent, and distilled spirits dropped 12.5 percent because baby boomers are drinking less and the number of people in the prime age drinking group (21-40) has decreased (Standard and Poor's, 1998). From 1989 to 1995, U.S. wine production, of which California's share is 90 percent, increased 2.7 percent. Wine exports, also dominated by California wineries, increased 400 percent between 1988 and 1997 (Wine Institute, 1998).

Table 11 shows that 84 percent of the electricity and 88 percent of the natural gas is used in the production of alcoholic beverages. Because of the internationally recognized wine country in the Napa Valley and other wine growing regions in California, alcoholic beverages also comprise the largest share of companies and jobs.

Table 11

California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)

Beverages

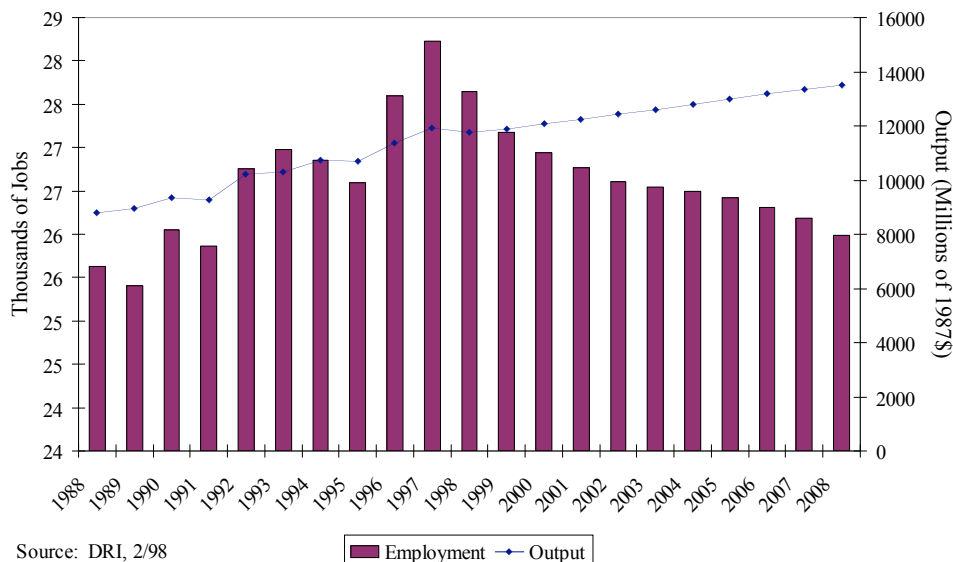
SIC	Description	Electricity (<u>million KWh</u>)	Natural Gas (<u>million therms</u>)	Establish <u>ments</u>	<u>Jobs</u>
208 2	Malt Beverages	300.7	28.6	60	3,819
208 3	Malt	*	*	2	*
208 4	Wines, Brandy and Brandy Spirits	642.7	25.7	428	16,339
208 5	Distilled and Blended Liquor	6.0	0.3	7	*
208 6	Bottled and Canned Soft Drinks	180.4	6.8	97	9,854
208 7	Flavoring Extracts and Syrups	10.5	0.9	68	1,548

* Confidentiality agreements do not allow public release of energy data in industries with less than 10 utility accounts.

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 11 shows increasing employment and output through 1997. While output is expected to rise from 1998 to 2008, employment is forecast to decline by .7 percent per year. This forecast implies rising productivity in the industry, due mostly to a 3.3 percent per year increase in output per job in the production of non-alcoholic beverages from 1998 to 2008. Productivity in the alcoholic beverage sector is also expected to improve but only at 1.8 percent per year.

Figure 11
Employment and Output in Beverages (SIC 208)



Miscellaneous Food Preparations and Kindred Products (SIC 209)

This category encompasses canned, cured, fresh and frozen fish, coffee, salty snacks, ice, macaroni and miscellaneous food preparations. Table 12 shows that food preparation (not elsewhere classified) is the largest electricity and natural gas user in this industry and has the largest number of companies and jobs. However, this segment of the industry is highly diverse and it serves as a classification “catchall”, thus its “large” size.

Other segments of the industry are roughly of comparable size in terms of number of establishments, jobs and energy use. California’s coastal location promotes its seafood processing industry (SIC 2091 and 2092). The preparation of canned fish and seafood and fresh fish accounts for more than 3,600 jobs. However, the industry is not likely to grow because some commercial fisheries are experiencing declining numbers of fish.

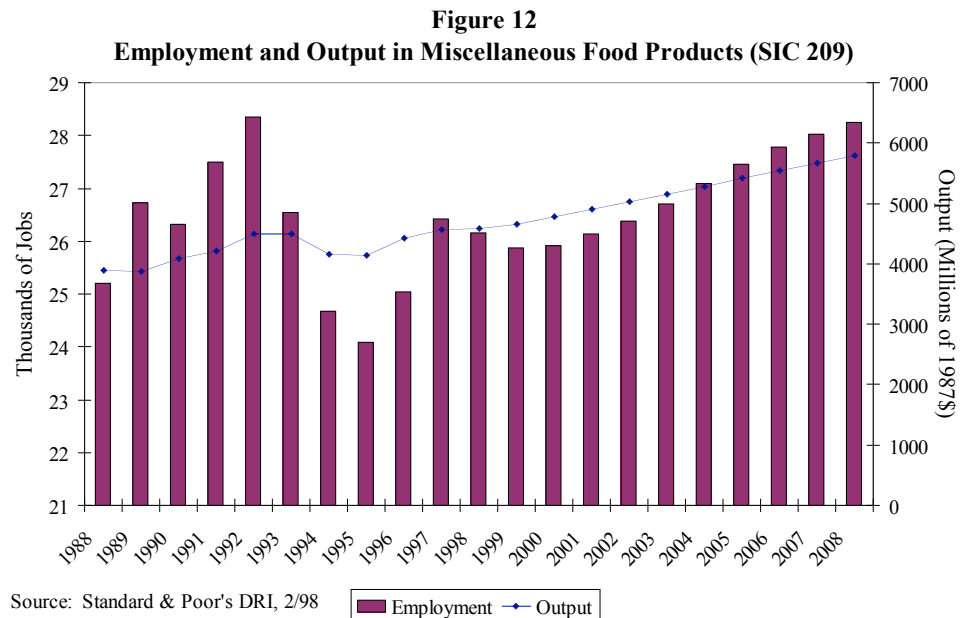
California also has 42 establishments in the potato chips and similar snacks sector. Although Frito-Lay tends to dominate the business nationally, and operates plants in California, the state has several other companies in this market. Many of these plants are producing corn chips to meet California’s taste for Mexican cuisine. The U.S. industry has seen consolidation and exit in the 1990’s, as Keebler left the industry and Eagle Snacks sold its business to Frito-Lay. The market in California is no less competitive than the national market but its diversity can support several independent companies.

Table 12**California Electricity and Natural Gas Consumption (1997), Establishments and Jobs (1996)****Miscellaneous Food Products**

SIC	<u>Description</u>	Electricity <u>(million KWh)</u>	Natural Gas <u>(million therms)</u>	Establish <u>ments</u>	<u>Jobs</u>
209 1	Canned and Cured Fish and Seafoods	44.2	1.5	29	1,519
209 2	Fresh or Frozen Prepared Fish	45.0	0.3	47	2,109
209 5	Roasted Coffee	22.1	2.4	35	1,015
209 6	Potato Chips and Similar Snacks	60.2	9.3	42	2,814
209 7	Manufactured Ice	65.0	0.1	45	677
209 8	Macaroni and Spaghetti	38.7	8.1	51	1,472
209 9	Food Preparation, NEC	278.5	33.9	342	12,410

Source: Quarterly Fuel and Energy Report (QFER) and California Trade and Commerce Agency

Figure 12 shows employment rising through 1992 and then falling until 1995. Employment has recently recovered some of the lost jobs and is expected to level out before increasing through 2008 by 0.9 percent annually. Output has been slowly increasing through 1998 and is forecasted to increase 2.6 percent per



year from 1998 through 2008.

References

- Standard and Poor's Data Resources, Inc., *U.S. Industry and Trade Outlook 1998*.
- Electric Power Research Institute, "Industry Brief, Dairy Industry," Palo Alto, 1991.
- Electric Power Research Institute, "Industry Brief, Sugar and Confectionary Products," Palo Alto, 1991.
- Electric Power Research Institute, "Industry Brief, Bakery Products," Palo Alto, 1994.
- Wine Institute, "U.S. Wine Exports Climb to \$425 Million in 1997," press release, San Francisco, 1998.

Appendix B

List and Locations of Selected Major Processing Sites within Each Sector

Fruit and Vegetable Thermal Processors (Canned and Aseptic Preservation)

Bell Carter Foods, Corning
Campbell Soup Supply Company, Sacramento, Dixon
DeFrancesco & Sons, Inc., Firebaugh
Del Monte, Modesto, Hanford
Escalon Premier Brands, Escalon
Gallo, Fresno
H.J. Heinz
Ingomar Inc., Los Banos
Kagome, Inc, Los Banos
Knudsen, Chico
Los Gatos Tomato Products, Huron
Lyons Magnus, Fresno
Morningstar Packers, Williams and Los Banos
Musco Family Olive Co., Tracy
Pacific Coast Producers, Woodland
Rio Bravo Tomato Company, Buttonwillow
Signature Fruit, Modesto
SK Foods, Williams
Smucker Fruit Processing Company, Oxnard
Stanislaus Food Products, Stanislaus
Sunkist, Tipton
Toma-tek (Neil Jones Food Company), Firebaugh
Unilever-Best Foods, Stockton (tomato)

Dehydrated Foods

Sunsweet Dryers, Yuba City

SunMaid Growers, Kingsburg
Conagra Foods, Gilroy
Mariani, Winters
Wilbur Packing Company, Yuba City
Traina Dried Fruit, Patterson
Valley Sun Products, Newman
Mooney Farms, Chico

Frozen Fruit and Vegetable Processing

J.R. Wood, Modesto
Patterson Frozen Foods, Patterson
Wawona Frozen Foods, Clovis
J.R. Wood, Atwater
Superb Farms

Fresh-Cut (minimally processed)

Bolthouse, Bakersfield (carrots)
Dole, Soledad
Fresh Express, Salinas
Gills Onions, Oxnard
Grimmway Farms, Bakersfield (carrots)
Naturipe Berry Growers, Salinas
River Ranch, Salinas



Dairy Processing Plants (compiled from the Top 100 list of Dairy Foods Magazine published August 2003) and other direct sources. Number represents national rank by sales, 2002)

Bongrain, (Advanced Food Products/Land O'Lakes), City of Industry, Los Angeles, Visalia (33)
 California Dairies Inc., Artesia, Fresno, Los Banos, Tipton, Turlock (17)
 Carvel Corporation, Commerce (55)
 Cheese and Protein International, (Land O'Lakes/Mitsui), Tulare
 Crystal Cream and Butter, Sacramento (63)
 Dairy Farmers of America, Modesto, Corona, Willows, Petaluma, Turlock, Ventura (9)
 Dean Foods, Buena Park, Hayward, City of Industry, Fullerton, San Leandro, Southgate, Tulare (1)
 Dreyer's Grand Ice Cream, City of Commerce, Union City (11)
 Foster Farms, Modesto, Fresno (47)
 Gossner Foods Inc., El Centro (80)
 Hilmar Cheese Company, Hilmar (30)
 Humboldt Creamery Association, Humboldt, Fortuna
 Ice Cream Partners, USA (Nestle/ Dreyers), Bakersfield, Tulare (27)
 Joseph Farms, Atwater
 Kraft and Kraft-Knudsen, Tulare, Visalia, (cold storage: Stockton, Ontario) (2)
 Kroger, Compton (7)
 Lactalis/Sorrento, San Jose, Turlock (22)
 Land O' Lakes, Tulare, Orland (3)
 Leprino Foods, Tracy and Lemorre East and West (10)
 Producer's Dairy Foods, Fresno (79)
 Safeway, Los Angeles, San Leandro (23)
 Santee Dairies Inc, City of Industry (59)
 Stremicks Heritage Foods, Cedar City, Riverside, Santa Ana (41)
 Superstore Industries (Sunnyside), Sacramento and Cordelia (51)
 Westfarm Foods, Los Angeles (14)

Meat and Egg Processing (Source: top 100 meat processors, Stagnitos, 2003,

Numbers after processors indicate company's national ranking in size by net sales where known)

Beef Processors

Beef Packers, Fresno (slaughter site)
 Brawley Beef, Imperial Valley (slaughter site)
 Bridgeford Foods Corp, Anaheim (73)

Central Valley Meat Company, Hanford (slaughter site)
Excel Corportion, Marysville (beef & pork) (2)
Golden State Foods, City of Industry (MacDonald's burgers)
Hallmark Meat Packing, Chino (slaughter site)
Harris Beef Company, Selma (slaughter site) (56)
Randall Foods, Vernon (42)
United Food Group, Vernon (49)

Poultry

Foster Farms, Livingston and Fresno (14)
Petaluma Poultry Processors, Petaluma
Zacky Farms, Fresno

Pork

Clougherty Packing Co. (Farmer John), City of Industry (slaughter site) (38)
Ito Cariani Sausage Co., Hayward (98)

Lamb

Superior, Dixon (62)

Eggs

NuLaid, Ripon

Wineries

Bronco Winery, Ceres, Escalon, Napa, Sonoma
Canandigua (Constellation Wines, US), Lodi
Franzia Winery, Ripon, Sanger
Gallo, Livingston

Aseptic Packaged Drinks and Soups (co-packers)

California Natural Products, Lathrop (rice dream, soups)

Creative Research Management

Pacific Choice Brands, Fresno

Nuts

Blue Diamond Almond Growers, Sacramento

Paramount Farms, Los Angeles (head offices)

Diamond of California, Stockton (walnuts)

Refrigerated Warehouses

77 locations in California (data from International Directory of Refrigerated Warehouses and Distribution Centers. 2003. International Association of Public Refrigerated Warehouses, Paris, France.

Appendix C

Food Industry Advisory Committee (FIAC) Members

The names and contact information of the FIAC members are as follows:

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Bob Bushnell (dairy)

President

Bushnell Industries, Inc.

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Dilip Chandarana (food processing)

Exec. Vice President, Scientific Affairs

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Jerry Cordy (tomato, food processing)

District Manager

Pacific Coast Producers

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Customer Energy Management

Industrial and Agricultural New Construction

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Appendix D

Examples of Other Industry Roadmaps and Visioning Reports

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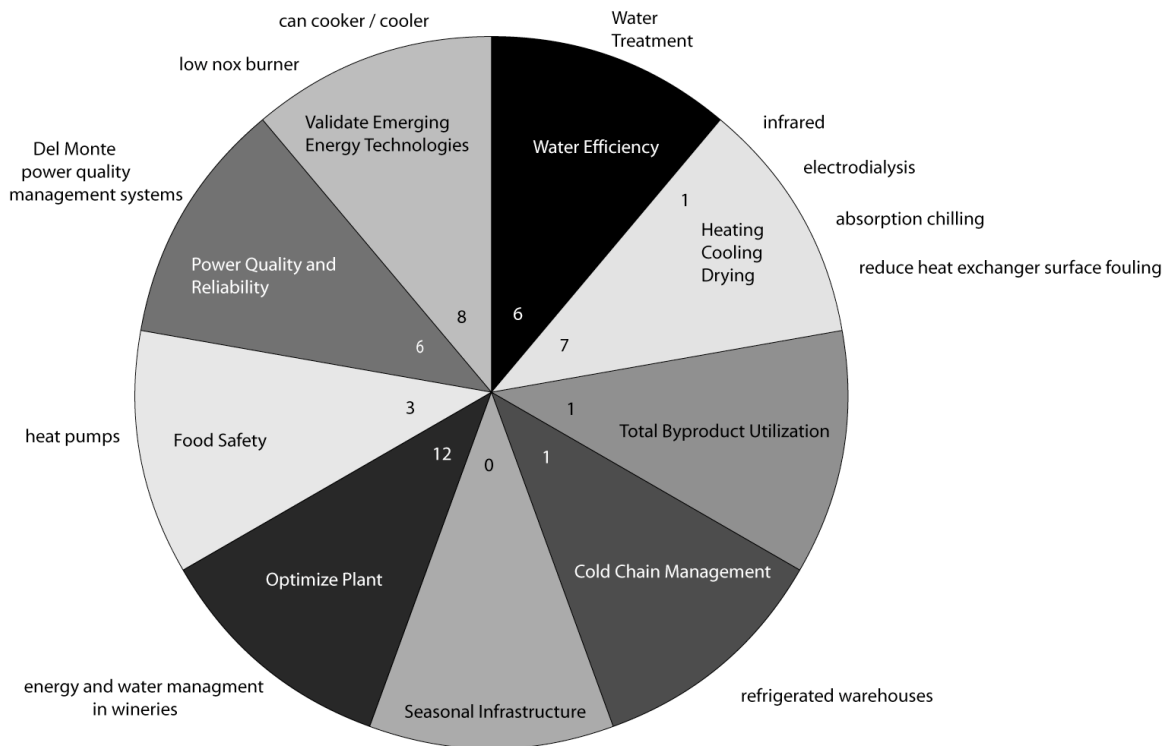
Appendix E

Concurrent Research, Development and Demonstration Projects

Based on the agenda and priority issues set by the Food Industry Advisory Committee, three short term RD&D projects were identified and funded in 2002/03, as well as a call for proposals initiated in Fall 2003. The program's portfolio will be expanded to include several industrial refrigeration RD&D projects to be funded in 2005.

Figure 1 represents the forty-four proposals submitted to the 2003 RFP with the number of proposals submitted for each need noted.

**Figure 1. Distribution of Proposals and Awarded Contracts
as a Function of Priority Needs**



Food Industry Energy Research (FIER) Program of the California Energy Commission has launched several RD&D projects conducted at research institutions and in food plants. These projects listed below and referred to in abbreviated form outside the circle in Figure 1, address a broad spectrum of research and RD&D targets included in the roadmap.

1. *Energy Efficient Ultra **Low NO_x** Burner (ULNB) Control Technology*
2. *Topping Cycle for Optimization of **Can Cooker/Cooler** Operation*
3. ***Infra Red** Drying of Rice to Improve Energy Efficiency*
4. *Waste Heat Driven **Adsorption Chilling***
5. *Integrated Benchmarking & **Energy & Water Management** Tool for the Wine Industry*
6. *Reduction of **Heat Exchanger Surface Fouling***
7. *Thermally Driven **Heat Pump** for Process Heating and Cooling*
8. *Tartrate Stabilization of Wines using **Electrodialysis***
9. *Energy Conservation in **Refrigerated Warehouses***

The potential energy savings from implementation of these projects is summarized in Table 1.

10.2. Table 1. Potential Energy Savings with R& D projects

10.2.1. Potential Energy Savings		
Project	Million kWh	kTherms
Heat Exchanger Fouling	15	6,300
Infrared Drying of Rice	128	11,800
Retort/Cooler Optimization	36	-470
Low NO _x Burner	65	0
Benchmarking Wineries	75	4,600
Adsorption Refrigeration	75	0
Wine Electrodialysis	28	0
Heat pump	3	380

The roadmap, and results of these projects, will be incorporated in a western state's food industry clearinghouse of information system providing technical assistance to industry managers (USDOE STAC Program funding, 2004/05). We hope the industry will find economic value in the information system to the extent of achieving energy efficiency improvements and cost savings.

Concurrent Model for Strategy Implementation

A good example and model for leveraging stakeholders and funds for water and energy research is a two-year project that began in April 2004. The California Energy Commission's Energy in Agriculture Program is a partner in this consortium, called the *State Technologies Advancement Collaborative (STAC)*. The goal of the project is to develop a body of knowledge about the food processing industry's

energy and water efficiency opportunities. STAC includes the development of energy-related Best Practices for the food industry as well as identification of new and emerging technologies. Stakeholders include the Oregon Department of Energy (Oregon), Washington State University (WSU) Energy Program, California Energy Commission (CEC), and Idaho Department of Water Resources Energy Division (Idaho), in cooperation with the Northwest Food Processors Association (NWFPA), the California League of Food Processors (CLFP), Northwest Energy Efficiency Alliance (Alliance), Lawrence Berkeley National Laboratory (LBNL), and Del Monte Foods. Funds principally come from federal sources (DOE, ASERTTI, and NASEO) through the *Western U. S. Food Processing Efficiency Initiative* that is being administered through the Oregon Department of Energy.

The expected outcome of this project is to substantially improve the energy and water use efficiency of the food processing industry in the Western states. At least six demonstration projects will be completed and an analysis and best practices portfolio will be assembled. Results will be disseminated via training and workshops. This will lay a foundation for the NWFPA and CLFP to establish and provide comprehensive efficiency services to all their members and other interested food processors. This work will leverage the expertise, interests, and resources of the Western states, the Alliance (a unique regional electric utility association), and LBNL (a national research laboratory). Partners will develop the definitive body of knowledge about food processing energy and water use efficiency opportunities and establish an effective framework for communicating that information.

This planning network and partnership, in conjunction with industry leaders, will have both forums and format to continue developing this resource and widen use within the national food and other interested manufacturing industry.

This network will serve as a "one stop" source for food industry energy-related information from U.S. DOE and state energy departments. One of the outcomes of the proposal will be the development of an Enterprise Energy and Asset Management (EAM) at Del Monte Foods that will be transferable to other U.S. manufacturing industries. Mr. Glen Lewis, of Del Monte Foods, who leads this effort has communicated this model to leaders of the food processing industry and follow-up collaborations are expected.

The STAC proposal has promised measurable energy savings and emissions reductions. Six or more demonstration projects will be completed with matching funds. Energy savings will exceed 7,300 million British thermal units (MMBtu) resulting from energy savings of 550,000 kilowatt hours per year and over 55,000 therms of natural gas.

Total project cost is \$1,627,777 and funding granted is \$730,652. Planned completion date is April, 2006.

Appendix F

Food Industry Energy Research Program of the California Energy Commission

Implementation of the Technology Roadmap has already begun. The Food Industry Energy Research (FIER) Program of the California Energy Commission has launched several RD&D projects conducted at research institutions and in food plants. These projects address a broad spectrum of research and RD&D targets included in the roadmap.

1. Energy Efficient Ultra Low NO_x Burner (ULNB) Control Technology

Air quality regulation has tightened the NO_x emission limits over the years. The reduction in NO_x is achieved by reducing the combustion temperature by flue gas recirculation or by increasing excess air. These methods increase airflow and in turn increase the electrical energy consumption. A typical 100 million Btu burner that in the past used a 50 hp blower to meet 100 ppm NO_x limit now requires 90 hp blowers to meet the current 30 ppm NO_x limit and will soon require 200 hp blower to meet the 9-ppm NO_x limit.

Flue gas recirculation is more energy efficient but reduces capacity. Ambient excess air is less energy efficient but capacity reduction is lower. A control strategy that will use less electrical energy while meeting emission limits has been developed by Alzeta Corporation, Santa Clara, California. The system will use a blower sized to provide full capacity with excess ambient air. It will operate exclusively with flue gas recirculation up to 82% full capacity. Above this level it will introduce excess ambient air and gradually increase its fraction so that at full capacity it operates on ambient excess air alone. This control strategy is estimated to save about 20% of electrical energy compared to alternative technologies.

The design of the control system and its testing in the in-house boiler was completed. Conversion of an 8.4 million Btu boiler to the new control system was completed at a commercial facility. A larger boiler installation at a food processing facility will be converted in 2004 to complete the project.

The benefits of this technology at a 50 million Btu/hr boiler is estimated at 18.4 kW reduction in peak demand and 40,800 kWh/year reduction in energy consumption at 50% capacity operation for 50% of the time.

2. Topping Cycle for Optimization of Can Cooker/Cooler Operation

Thermal processing of fruits and vegetables involves heating the cans in a retort followed immediately by cooling the cans using ambient or chilled water. Steam is used for heating while electricity is used to drive chillers. Steam is generated at pressures around 150 to 250 psi in boilers using natural gas. The steam pressure is reduced by valve to about 50 psi for heating the retorts. This pressure reduction results in a tremendous loss of energy or availability to produce mechanical work although net thermal energy is conserved.

In a topping cycle plant, steam pressure is reduced in a steam turbine while producing useful mechanical work and the exhaust steam used for process heat. The heat content of exhaust steam is lower due to extraction. Therefore, the process requires more steam hence more thermal energy input. However, the

efficiency of conversion of additional thermal energy to mechanical work approaches 100%. These results in substantial energy savings compared to a thermal power plant operating at around 40% efficiency.

Implementation of a topping cycle system at the Del Monte Plant in Modesto, California to drive a refrigeration unit at a fruit canning plant is estimated to save 1.1 million kWh of electricity per year and reduce the peak load by 111 kW while using 30,000 therms of supplemental thermal energy.

Installation of the machinery is expected to commence once supplemental funding is secured.

Optimization of cooker-cooler operation using topping cycle will have far reaching effects on fruits and vegetables industry sector in California which consumes 390 million kWh of electricity and 258 Million therms of natural gas annually.

3. Infra Red Drying of Rice to Improve Energy Efficiency

Conventional grain drying forces large volumes of hot air through deep beds of grain. This process depends on convection to transfer heat from hot air to grain surface and conduction to transfer heat to the interior of the grain. Infrared process heats the grain by radiation. Electromagnetic waves in the infrared band 3 to 10 microns penetrate up to 3 mm in to the grain and heats it faster and more effectively. Preliminary tests have shown that infrared drying can reduce gas consumption by 25% and electricity consumption by 80% compared to conventional column dryers.

Laboratory scale flameless catalytic infrared dryer and a selective wavelength electric infrared dryer at UC Davis are being used to conduct experiments on infrared drying of rice at present. These tests will establish optimum operating parameters and effectiveness of infrared treatment on disinfestations and reducing microbial counts. A large scale dryer will be tested with rice and the results compared with laboratory tests.

California produces about 21 million tons of rice annually. Rice is harvested at average moisture content of 21% and dried to less than 14% for safe long-term storage. Drying down to 17% is done in column dryers using hot air and final drying to 14% moisture is done with ambient air in the storage bins. A typical 50 ton/hour column dryer uses about 1.9 therms of natural gas and 7.7 kWh of electricity per ton of rice. This dryer will reduce peak demand by 100 kW, electrical energy consumption by 152,500 kWh/year and the gas consumption by 12,000 therms per year by using infrared drying.

4. Waste Heat Driven Adsorption Chilling

Refrigeration is the most electrical energy intensive unit operation in the food processing industry. There is a strong interest to use waste heat driven refrigeration technology in food processing plants. Waste heat in food processing plants is available at relatively low temperatures typically below 200F. This is too low for optimal operation of ammonia and lithium bromide based absorption refrigeration technology.

Adsorption technology is better suited for conversion of low temperature waste heat to chilling compared to absorption technology. This process uses water as the refrigerant and silica gel as the adsorption agent. Water evaporates at low pressure to provide refrigeration. Water vapor is adsorbed by silica gel. Waste heat in the form of hot water regenerates silica gel and releases water vapor. Water vapor is condensed and returned to the evaporator and silica gel is reused as adsorbent.

A 300-ton adsorption chiller will be installed at a Frito-Lay French fry plant. The plant processes about 20,000 lb/hr of potato chips producing about 15,000 lb/hr of water vapor at about 220 F. This water vapor

discharged to the atmosphere at present, will be used as the heat source for the adsorption chiller. The chiller will provide cold water for air conditioning of the plant. This installation is estimated to save about 1.5 million kWh per year and 270 kW of demand. The final engineering report on the installation was completed and approved by the Frito-Lay plant management. Ordering equipment and the installation process is expected to commence during the summer of 2004.

5. Integrated Benchmarking & Energy & Water Management Tool for the Wine Industry

Wine making is an important sector in the California Food Industry and also a considerable energy consumer. It uses about 406 million kWh of electricity and 23 million therms of thermal energy annually. The process water use has been reported to be between 2 to 6 gallons per gallon of wine.

A team of scientists from Lawrence Berkeley National Laboratory is working to develop a benchmarking and energy efficiency screening tool to help wineries determine their energy and water efficiency. The tool consists of several components combined in an easy-to-use package. A process based benchmarking module calculates an energy efficiency index (EEI) allowing for characteristics of each process. This index, EEI, allows comparison of different wineries and a specific winery over time. A similar index will be developed for water efficiency.

The tool includes an assessment of energy and water efficiency technologies. It provides energy and water efficiency improvement that can be achieved with each measure in a given plant. This tool will facilitate awareness of energy and water use and encourage the comparison amongst similar facilities and provides a fast and efficient way to evaluate the impact of potential energy efficiency improvements. The tool is being developed in collaboration with Fetzer Vineyards, tested in a number of wineries and disseminated to all wineries in California through California Wine Institute. Data collection at the winery is in progress.

6. Reduction of Heat Exchanger Surface Fouling

Heating of liquids is a common unit operation in food industry, pasteurization of liquid milk and concentration of fruit and vegetable juices being two examples. Thermal instability of food components results in formation of fouling layers in food processing equipment. Fouling increases thermal energy use by decreasing heat transfer coefficient and increases electrical energy use by increasing pressure drop along the heat exchanger. Fouling further increases both thermal and electrical energy consumption by increasing frequency and duration of cleaning operations.

The increase in electrical energy consumption in US pasteurized liquid milk industry alone due to fouling is estimated at 92 million kWh per year and the increase in thermal energy consumption at 39 million therms during the year 1990-91. Fouling increases cost of food plant operations by increased cost of oversized equipment, increased downtime, increased energy, water and chemical consumption for cleaning. Fouling was estimated to cost US pasteurized liquid milk industry alone \$104 million in 1991.

Coating the heat exchanger surfaces with graded electroless Nickel- Phosphorus-Polytetrafluoroethylene (Ni-P-PTFE) has been found to reduce the rate of fouling and also to make cleaning of fouled surfaces easier. This technology is expected to dramatically reduce cost and fouling related energy consumption in food industry applications.

A research project to compare standard stainless heat exchangers with coated heat exchangers by measuring heat transfer and pressure drop characteristics will be conducted by a team of researchers at Pennsylvania State University. These tests will validate possible thermal and electrical energy savings. It will investigate the peeling of the coating and device methodology for its prevention. The tests will be conducted with dairy products, tomato juice and fruit juices, which are major component of California's food processing industry. The project has not commenced yet due to contractual difficulties.

11.0 7. *Thermally Driven Heat Pump for Process Heating and Cooling*

Many food and beverage industries require heating and cooling for process and storage applications. Gas fired boilers or water heaters are used to supply heating while electrically driven refrigeration systems are used to provide cooling. The cost of energy consumed by these devices is a major concern of the industry. Heat pumps are devices that pump heat from a lower temperature to a higher temperature. In effect they produce refrigeration at a lower temperature and heat at a higher temperature at the same time. They have the potential to supply both heating and cooling in processing applications where both are required.

Energy Concepts Company has developed an improved gas-fired heat pump that can produce high temperatures required in industrial water heating while co-producing substantial cooling effect. A 30-ton gas-driven heat pump unit delivers 360,000 BTU of refrigeration and 810,000 Btu of heating while using 3 kWh of electricity and 510,000 Btu of gas per hour. A 10 ton unit has been installed at a poultry plant and another installation is planned.

This technology has the potential to reduce electrical energy consumption by about 80% and thermal energy consumption by about 40% compared to conventional technology when both cooling and heating capacity are fully utilized. Poultry, dairy, and brewing are food industry sectors require heating and cooling within the limitations of this technology.

12.0 8. *Tartrate Stabilization of Wines using Electrodialysis*

Tartrates of potassium and calcium occur naturally in grapes at near saturation levels. These salts tend to form precipitates in wine during storage. Tartrate stabilization reduces the concentration of these salts to safer levels to prevent precipitation. Cold storage is the methods used predominantly in United States for this purpose. This is a highly electrical energy intensive process requiring over 70 kWh per 1,000 gallons of wine.

Electrodialysis is an electrically driven membrane process that separates ionized solutes from aqueous solutions. It is widely used for desalination of seawater, demineralization of whey and many other applications. Recent advance in membrane development has enabled application of this technology for tartrate stabilization of wines. Electrodialysis uses about 12 kWh per 1000 gallons of wine hence less energy intensive compared to cold stabilization. It can produce better quality wines.

A pilot electrodialysis system rated at 250 gallons of wine per hour was tested at two wineries during 2001 wine season. Electrodialysis of wine produced samples with equivalent or better quality compared to conventional treatment. The process used a fraction of the electrical energy compared to the conventional treatment as expected. Removal of several undesirable compounds was seen as a further advantage of the process. The process allows better control and eliminates the cumbersome sample testing involved with the conventional process.

A demonstration project involving a 600 gal/hr mobile electrodialysis system was launched in collaboration with Wine Secrets, a wine industry service company in Napa Valley. This unit has conducted demonstration at six wineries. A stationery unit with 2,500 gal/hour capacity is expected to be installed shortly.

California has over 800 wineries and wine industry is estimated to contribute \$33 billion annually to the California economy. Introduction of new technology is essential to California wine industry to retain its competitiveness.

13.0 9. Energy Conservation in Refrigerated Warehouses

California has about 75 public refrigerated warehouses with over 300 million cubic feet of cold storage volume and consumes about one billion kWh of electricity annually. In there are as many private refrigerated warehouses. This sector is responsible for about 20% of the total electric energy consumption of the food industry. Several RD&D activities in the refrigerated warehouse will be undertaken in consultation with the International Association of Refrigerated Warehouses (IARW).

A survey of the industry will be conducted to determine the energy use and energy efficiency of the refrigerated warehouses in California. This survey will also Review the RD&D opportunities presented by programs of IARW, CEC, PUC, utilities, universities and other public and private organizations.

The heat removal rate during blast freezing decreases as the product cools and the need for air circulation decreases. However, in current practice the fans operate continuously wasting considerable amount of electrical energy. Blast freezer fan modulation reduces the fan speed to match the cooling load and reduces the energy consumption.

Frosting of coils is another major cause of energy waste in refrigerated warehouses. This can be minimized by using desiccants to remove moisture from air. The desiccant has to be regenerated using heat. Hybrid systems will use turbines or engines to drive the refrigeration system and the waste heat will be used to regenerate the desiccant. Projects to demonstrate blast freezer fan modulation and integrated hybrid refrigeration system will be implemented at public refrigerated warehouse facilities.